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VOLUME 16 NOVEMBER, 1957 NUMBER 4

CONTENTS

	Page
The Calorie Value of TDN. R. W. Swift	753
Studies on Forage Utilization by Steers and Sheep. J. L. Hull, J. H. Meyer, G. P. Lofgreen and A. Strother	757
Selective Grazing by Sheep and Cattle. J. H. Meyer, G. P. Lofgreen and J. L. Hull	766
Behavior Patterns of Sheep and Cattle Being Fed Pasture or Soilage. G. P. Lofgreen, J. H. Meyer and J. L. Hull	773
Cellulolytic Interrelationships of Carbohydrates, Fat and Trace Minerals in Sheep Rations. C. E. Summers, F. H. Baker and R. B. Granger	781
Self-Feeding Free Choice vs. Self-Feeding a Complete Mixture for Fattening Steers. W. M. Beeson, T. W. Perry and Martin Mohler	787
Ruminant Utilization or Inorganic Phosphates. C. B. Ammerman, R. M. Forbes, U. S. Garrigus, A. L. Neumann, H. V. Norton and E. E. Hatfield	796
The Effects of Adequate and Excessive Calcium When Fed With Adequate Phosphorus in Growing Rations for Beef Calves. T. W. Dowe, J. Matsushima and V. H. Arthaud	811
Effect of Feeding Stilbestrol and Urea on Ration Digestibility and on Retention of Calcium, Phosphorus and Nitrogen in Lambs. M. C. Bell, J. R. Taylor and R. L. Murphree	821
Effects of Fat, Oxytetracycline and Stilbestrol on Performance and Hepatic Stores of Carotene and Vitamin A in Steers. I. A. Dyer, M. E. Ensminger and R. L. Blue	828
The Effect of Chlortetracycline, Stilbestrol and Animal Fat on Fattening Steers. V. R. Bohman, M. A. Wade and J. E. Hunter	833
The Effect of Various Levels of Stilbestrol and Nor-Testosterone Implants on Lambs. R. M. Jordan	840
Combination of an Antibiotic and a Female Hormone for Fattening Steers. W. M. Beeson, T. W. Perry, Martin Mohler, F. N. Andrews and Martin Stob	845
Strain Differences in the Estrogenicity of Alfalfa. Martin Stob, R. L. Davis and F. N. Andrews	850
Effect of Para Amino Salicylic Acid and Chlortetracycline Alone and in Combination on Dairy Calves. J. M. Wing	854
The Influence of Sodium Bentonite *In Vitro* and in the Ration of Steers. E. S. Erwin, C. J. Elam and I. A. Dyer	858
Some Effects of Pelleting a Ground Mixed Ration on Feed Utilization by Fattening Lambs. A. L. Esplin, U. S. Garrigus, E. E. Hatfield and R. M. Forbes	863
A Method of Feeding Supplements to Individual Cattle on Winter Range. L. E. Harris, J. C. James and C. W. Cook	872

Page

Effect of Gestation Diets and Creep Feeding on Livability and Weight Gains of Suckling Pigs. J. W. Stevenson and N. R. Ellis 877

Protein and Fat Requirements of Baby Pigs. E. R. Peo, G. C. Ashton, V. C. Speer and D. V. Catron 885

The Influence of Calcium Pantothenate, Trytophan and Methionine Supplementation and Source of Protein Upon Performance of Growing Swine Fed Corn-Meat and Bone Scraps Rations. R. J. Meade and W. S. Teter 892

Subcutaneous Stilbestrol Implantation in Growing-Fattening Swine. Hubert Heitman and M. T. Clegg 901

Some Effects of Feeding Animal Fat and N, N'-Diphenyl-P-Phenylenediamine to Swine. J. T. Gesler, M. E. Ensminger and C. J. Elam 911

Feeding of Crude and Modified Menhaden Oils in Rations for Swine. J. E. Oldfield and A. F. Anglemier 917

Feeding of Various Levels of Pilchard (California Sardine) Oil to Swine. A. F. Anglemier and J. E. Oldfield 922

The Effect of Method of Feeding Upon the Susceptibility of the Pig to Parakeratosis. P. K. Lewis, R. H. Grummer and W. G. Hoekstra 927

The Effect of Mineral and Phenothiazine Supplementation on the Resistance of Grazing Lambs to *Haemonchus Contortus* Infection. R. J. Emerick, W. J. Bemrick, A. L. Pope, W. G. Hoekstra and P. H. Phillips 937

Ascaricidal Activity of Piperazine Administred in the Feed to Swine. J. E. Guthrie and J. E. Briggs 943

The Relationship of Ration and Inheritance to Eating Quality of the Meat From Yearling Steers. Sylvia Cover, T. C. Cartwright and O. D. Butler 946

A Photographic Grid Used to Measure Rib Eye Areas. C. O. Schoonover and P. O. Stratton 957

The Creatinine Level of Blood Serum as an Indicator of Carcass Composition. P. R. Wuthier and P. O. Stratton 961

The Effect of Progesterone on the Estrous Response of Estrogen-Conditioned Ovariectomized Cows. R. M. Melampy, M. A. Emmerson, J. M. Rakes, L. J. Hanka and P. G. Eness 967

Factors Affecting Fetal Pig Weight Late in Gestation. D. P. Waldorf, W. C. Foote, H. L. Self, A. B. Chapman and L. E. Casida 976

The Maintenance of Early Pregnancy in the Ovariectomized Ewe by Injection of Ovarian Hormones. W. D. Foote, L. D. Gooch, A. L. Pope and L. E. Casida 986

Multiple Birth and Sex Ratio in Rahmani Sheep. H. A. Karam 990

Economic Importance of Traits and Selection Indexes for Beef Cattle. H. B. Lindholm and H. H. Stonaker 998

Studies on Bovine Ocular Squamous Carcinoma ("Cancer Eye") III. Inheritance of Eyelid Pigmentation. D. E. Anderson, Doyle Chambers and J. L. Lush 1007

Abstracts of Papers at Annual Meeting 1017

Subject Index of Abstracts 1115

Author Index of Abstracts 1119

News and Notes 1123

Subject Index of Original Articles 1125

Author Index of Original Articles 1128

THE CALORIC VALUE OF TDN[1, 2]

R. W. SWIFT

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THROUGHOUT a period of many years, especially during the last decade, there has developed an appreciation of the shortcomings and inaccuracies inherent in the determination of total digestible nutrients as a measure of the potential nutrient value of feeds. With this development has come the realization that a simple counterpart—the direct determination of the total energy content of the feed and of the feces by means of the bomb calorimeter affords a simple, direct and accurate measure of the digestible energy which is measured in calories—in common with other systems of nutritive measurements for livestock and human populations.

Nearly 25 years ago, Overman and Gaines (1933) made the following statement: "So far as dairy cows alone are concerned, it would appear entirely sufficient to determine for the various feeding stuffs simply the content of energy and protein and the digestibility coefficient for these two items". Since that time there have been numerous publications from several different laboratories pointing out the inaccuracies of the cumbersome empirical procedures involved in the determination of total digestible nutrients. Maynard (1944) in an Editorial Review has cautioned against widespread use of average approximate values and in a later review (1953) points out inherent errors in the use of total digestible nutrients as a measure of feed energy. Schneider (1954) in a rather exhaustive treatise on the total digestible nutrient system of measuring nutritive energy points out that it is lacking in scientific concepts and nutrition theory as compared with other measures of nutritive energy.

"In the determination of total digestible nutrients, the feed and feces are separated in a manner of speaking by empirical chemical analyses into component parts. The digestibility of each component (crude fiber, nitrogen-free extract, etc.) is determined and in accord with their respective digestion coefficients the parts are reassembled to constitute a total digestible nutrient value expressed on a weight basis. The underlying energy aspect of the process is tacitly recognized by giving the same weight value to digestible protein and carbohydrate and by multiplying the digestible ether extract by 2.25 before including it in the TDN appraisal." (Swift *et al.*, 1950).

[1] Authorized for publication on May 2, 1957, as paper no. 2146 in the Journal Series of the Pennsylvania Agricultural Experiment Station, University Park.

[2] This study was part of a Northeast Regional Project, NE-24 "The Nutritive Evaluation of Forages", a cooperative study involving agricultural experiment stations in the Northeastern Region, the Dairy Husbandry Research Branch, USDA, and the U. S. Regional Pasture Research Laboratory and supported in part by regional funds.

It may be somewhat surprising that the suggestion of Overman and Gaines was not generally advocated and adopted by other workers interested in the determination of digestibility, for it is indeed difficult to deny the over-all significance of digestible energy, and an application of this philosophy to the whole field of digestibility with all species of animals would seem to have much in its favor.

Considering that a major function of feedstuffs, especially carbohydrates, is to furnish energy, it is logical to concentrate attention on digestible energy without regard to whether its originates in starch, cellulose, or "crude fiber." The determination of energy values by the bomb calorimeter is one of the most accurate analyses performed in the laboratory and it seems that a valuable and direct evaluation of the digestibility of feedstuffs has been overlooked. The final evaluation of feeds by this method would thus be closely comparable to TDN but would be the direct result of only one accurate analysis of the feed and one of the feces.

The determination of digestible energy avoids the tortuous method involved in obtaining total digestible nutrients and possesses the greater significance accruing to a more direct procedure. It serves the same purpose with increased simplicity and accuracy. As a matter of fact the determination of total digestible nutrients may be looked upon as a laborious, cumbersome and inaccurate effort to determine digestible energy.

About 10 years ago the author sent a statement to this effect to some 15 prominent workers in the field with the suggestion that digestible energy be adopted in the place of TDN. Replies revealed complete agreement as to the superiority of this experimental procedure as being more easily and directly determined, more accurate and with results expressed as calories. Pursuing the matter further, Dr. B. H. Schneider and the author in 1948 recommended to the Committee on Animal Nutrition of the American Society of Animal Production that digestible energy be adopted as a routine measure of the potential value of feedstuffs in the place of TDN.

The Committee on Animal Nutrition was sympathetic toward the suggestion and appreciative of its soundness but was reluctant to make any abrupt change due primarily to the fact that there was no reliable basis for expressing the vast number of TDN values accumulated throughout a period of many years, on the digestible energy basis. The general philosophy was not discarded however and since then, from time to time the desirability of adopting digestible energy, in the place of TDN has been expressed by various workers in the field (Lofgreen, 1951; Maynard, 1953; Schneider, 1954; Crampton, 1956). Digestible energy has been adopted as the common yardstick of nutritive value by the Northeast Regional Technical Committee in comparing forages (Swift, 1957) and the use of the term, "digestible energy", is becoming increasingly common in current reports of nutrition research.

The question of the caloric equivalent of a pound (or Kg.) of TDN

has received some attention in the past. A value of 1814 Calories per pound of TDN, originating some 30 years ago seems to have been derived by multiplying the number of grams in a pound by 4 (4 Cal. per gm. $\times$453.6 gm. per lb.=1814). Brody (1934) refers to this value as, "a conventional equivalent used, for example, in Sherman's textbook". From a vast amount of data Schneider (1947) reasoned that a more nearly correct value would be in the neighborhood of 1987 Cal. per lb. of TDN. This general contention was supported by Maynard (1953) in his review. Crampton (1956) presented evidence based on theoretical considerations that in swine nutrition a pound of TDN should be equivalent to about 2037 Calories of digestible energy while the corresponding value indicated for sheep was 1991 Calories.

The main problem involved in the adoption of digestible energy seems to be one of salvaging the TDN values now on hand. The main objective of this paper is to report the results of a study based on experiments in which both TDN and digestible energy were determined and in which identical samples of feed and of feces were invloved. Since both TDN and digestible energy represent a feed-feces difference, it can be taken for granted that a high degree of correlation must exist between the two yardsticks, allegedly measuring the same thing.

In order to establish the caloric value of a pound of TDN on a completely sound basis, the author assembled all available values from this country and abroad which furnished a TDN value and a digestible energy value, experimentally determined from one and the same collection period. No assumptions nor computations were made other than dividing the calories of total digestible energy, as determined, by the pounds of TDN as determined in the same experiment. The author is indebted to Dr. T. A. Long for the arithmetic and statistical checking of the data.

A total of 312 such individual values was obtained. It was hoped at the outset that an even larger number might be secured but it seems likely from a study of these 312 reliable values that a larger number would merely confirm the present findings. These 312 values (Cal. per lb. TDN) were listed in 3 divisions, (1) cattle, roughage alone (50 values), (2) cattle, mixed rations (71 values), (3) sheep, roughage alone (191 values). A summary of the findings is presented in the following table:

TABLE 1. THE CALORIC VALUE OF A POUND OF TDN

Feed	Species	No.	Calories per lb. TDN [a]	St. error	Coeff. variation
					%
Roughage	Cattle	50	1996	8.7	3.1
Mixed rations	Cattle	71	1982	4.1	1.7
Roughage	Sheep	191	2007	4.2	2.9

[a] Kilocalories.

A statistical analysis of the data by the "t" test (Snedecor, 1946) shows that the difference between any two of the three means does not approach significance even at the 5% level. The average or mean value of the 312 determined values is 1999.4 Calories per pound of TDN (standard error 3.1, coefficient of variation 2.8%).

For practical purposes, to convert TDN to digestible energy we may, therefore, simply multiply the weight of TDN in pounds by the factor, 2000 to obtain its equivalent in Calories. In view of Crampton's report (1956), it appears that this value is also applicable to swine. This relationship, based exclusively on experimentally determined values should resolve the question of the energy value of a computed weight of a group of materials known as total digestible nutrients.

Summary

A study of data obtained from 312 digestion experiments in which both digestible energy and total digestible nutrients were experimentally determined revealed that one pound of total digestible nutrients is equivalent of 2000 Calories of digestible energy. This value was found to apply to sheep and cattle on roughage alone and to cattle on mixed rations.

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STUDIES ON FORAGE UTILIZATION BY STEERS AND SHEEP

J. L. Hull, J. H. Meyer, G. P. Lofgreen and A. Strother
University of California [1, 2]

A PREVIOUS report from this station (Meyer *et al.*, 1956) gives the comparative production by beef steers fed alfalfa forage as hay, pasture or soilage. Daily gains were the same for the steers fed alfalfa as pasture and soilage, but were lower for those fed alfalfa hay. Greater production per acre was realized from the steers fed alfalfa soilage and hay compared to the pasture lots. There is no adequate information on the comparative production from beef cattle and sheep when fed the same forage either as soilage or pasture. A factorially designed experiment was conducted to compare the gains and feed utilization of sheep or cattle when given soilage or pasture from alfalfa or trefoil-orchard grass forage.

Experimental

This experiment was conducted at the University Farm at Davis during the months of June through October, 1956. Eight treatments were used: steers fed alfalfa as pasture or soilage; steers fed trefoil-orchard grass as pasture or soilage; sheep fed alfalfa as pasture or soilage; and sheep fed trefoil-orchard grass as pasture or soilage.

Adjacent fields of alfalfa and trefoil-orchard grass were used. The alfalfa was a pure 5-year old stand while the trefoil-orchard grass (Lotus corniculatus, narrow leaf, and Dactylis glomerata, Akaroa) was a new planting. The layout of the two different forage fields was similar to that of figure 1, Meyer *et al.* (1956). Each field was divided into six blocks. All treatments for the given forage were assigned to each block.

Prior to the beginning of the experiment, the first cutting of forage from each field was harvested and not used for the experiment. The blocks were harvested at this time at 6-day intervals by a forage chopper so that later as the experiment progressed from one block to the next, the forage would be approximately the same stage of maturity. During the experiment, the alfalfa was harvested or grazed between 10 and 50% bloom while the trefoil-orchard grass was harvested or grazed while still in the vegetative stage. Both fields were adequately irrigated throughout the season.

Eighty head of good-to-choice cross-bred feeder lambs (Suffolk×whiteface range ewes) were divided at random into four lots of 20 head each and assigned to the four experimental treatments. Forty head of good-to-

[1] Animal Husbandry Department, Davis.

[2] The authors are pleased to acknowledge the suggestions of Professors M. L. Peterson and L. G. Jones, Department of Agronomy in the plan and design of these experiments.

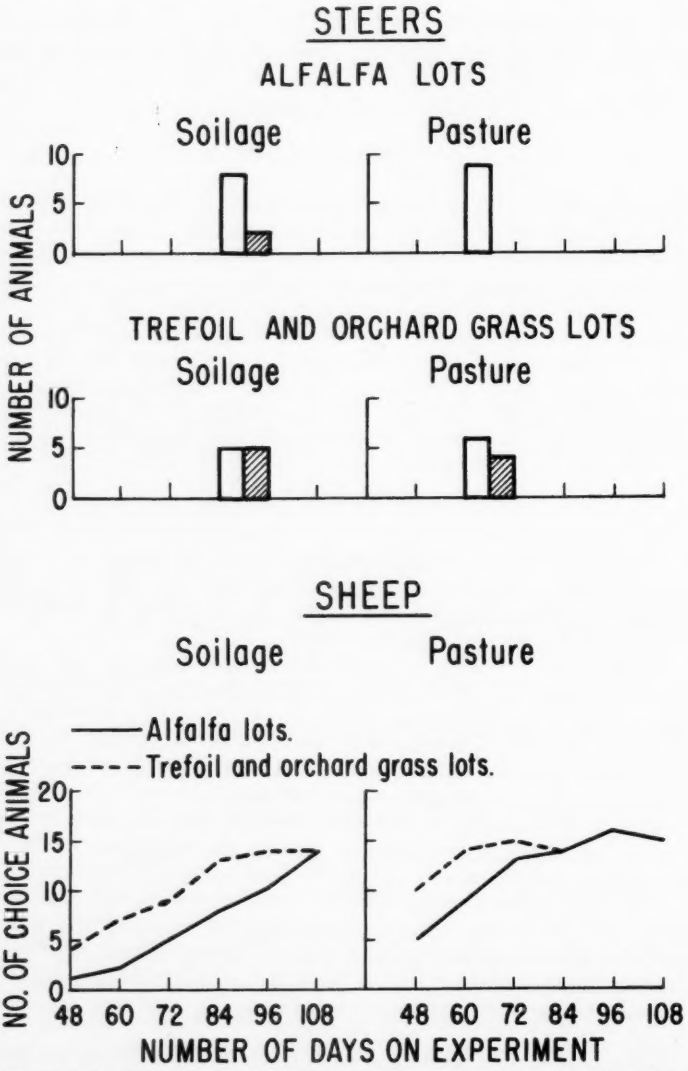

Figure 1. A graphical presentation of the slaughter grades of the animals. The bars in the upper graph which are blank indicate the number of steers grading standard at the end of the experiment while the cross-hatched bars represent the number grading good. The sheep were graded each weigh period and shown are the number in the choice grade. The remaining sheep were graded as good.

choice Aberdeen Angus feeder steers were obtained 45-days prior to the beginning of the experiment so that 16 animals could be trained for fecal collection purposes. The steers were divided at random into four lots of 10 head, each lot containing 4 of the trained steers, and assigned to the four experimental treatments. During the last month of the experiment because of the slower growth rate of the forage, three steers and six sheep had to be taken from each treatment so as not to limit the amount of feed available for the remaining animals. All animals were weighed every 12 days after a 14-hour stand without feed or water. The animals grazed and were fed soilage for 12 days before the initial weight was taken. This was done to standardize weighing conditions.

It was found necessary to feed 3 to 5 lb. of Sudan grass hay to the steers given alfalfa pasture to help control bloat. The feeding of Sudan grass hay seemed to effectively control bloat but it was found advisable to limit the duration of time they were allowed to graze when first given access to fresh forage at the start of a new block. An attempt was made to feed all animals equivalent intakes of Sudan grass hay so that similar feed would be consumed.

Fecal counts were made for internal parasites on the steers and sheep before the experiment started. Even though practically no eggs were found, all animals were treated for stomach worms. The alfalfa pasture had never been grazed by ruminants while the trefoil-orchard grass pasture was a new seeding and animals had not been in the field for the preceeding two years. Consequently, it was felt that internal parasites would not interfere with the interpretation of the data.

The animals were grazed or fed soilage from each block for a 6-day period so that the forage always had a 30-day recovery time. An attempt was made to obtain the same intensity of grazing between the steers and sheep. A fence was used to adjust the area of each block to a size so that the animals would graze each pasture at the same intensity. All forage refused by the pasture lots was field chopped and taken from the field after each grazing.

Soilage was harvested with a flail type forage harvester. All soilage, hay and feed weighbacks were weighed and sampled for dry matter analysis.

After a 5-day preliminary period in block 3 fecal collections were made for six days in block 4. The collection period was repeated three times when the animals received their forage from blocks 3 and 4. Three steers and five sheep were used in each lot for digestibility studies. Digestibility and forage consumption for the steers were measured by the chromogen-chromium oxide technique of Reid *et al.*, (1952). The chromogen method was used for digestibility for the sheep but fecal collection harnesses were used to measure quantative fecal excretion. The chromic oxide determination used was that described by Bolin *et al.*, (1952).

It was found during the laboratory analyses that there was a large per-

centage of silica present in the feces and forage. This percentage of silica, as analyzed in the feces, varied from 2% for the animals given pasture, and a high of 27% for those fed soilage. This silica on the forage came from the dust picked up by the forage harvester and the dust from roads. All results were then calculated on a silica-free basis since erroneous results were obtained if this correction was not made.

When the amount of meat produced from forage alone was calculated, adjustments were made for the Sudan grass hay consumed. Morrison's (1948) net energy values for Sudan grass hay, green alfalfa, and clover and mixed pasture (well grazed) were used to apportion the meat produced from hay or soilage. For the pasture animals, it was assumed that the same gain would occur per unit of Sudan grass hay consumed as that found for the animals fed the corresponding soilage. Corrections could be made for the gains due to Sudan grass hay and subtracted from the total meat produced to obtain the meat produced from the forage alone.

Analysis of variance (Snedecor, 1946) was used for the statistical analysis and the method of least significant difference was used to determine significance between treatments.

Results

A summary of the results for the 108-day trial is presented in table 1. The daily gains for the steers given alfalfa were significantly lower than for the steers given trefoil-orchard grass forage. Daily gains for the sheep pasture lots were significantly greater at the 1% level than the daily gains of those fed soilage.

Soilage consumption on a dry basis was equal within plant species even though weight of green forage consumption varied. Sudan grass hay consumption by the steers was about equal except more was required to control bloat in the alfalfa pasture steers. The sheep lots had access to dry hay but the sheep on pasture would consume very little.

Comparisons of the meat production per acre for the 108-day experiment are presented in table 2. The values given for pounds of meat produced per acre have been corrected for the Sudan grass hay consumed and represent only that meat produced per acre from the respective forages. An increase in meat production amounted to 25% for the cattle given soilage compared to those grazing while for the sheep the increase was only 5%. The relative increase in production from soilage was not materially different from either alfalfa or trefoil-orchard grass forage. When these data were combined, there was a statistically highly significant difference between the soilage and pasture lots in favor of soilage.

The number of steers given trefoil-orchard grass which graded in the good slaughter grade was greater than the number in the groups fed alfalfa as soilage or pasture. The lambs on pasture reached a choice slaughter grade sooner than the lambs fed soilage. It was also found that the lambs

TABLE 1. RESULTS FROM FEEDING ALFALFA AND TREFOIL-ORCHARD GRASS FORAGE

	Steers				Sheep			
	Dry lots		Pasture lots		Dry lots		Pasture lots	
	Alfalfa Soiling	Trefoil and orchard grass Soiling	Alfalfa Grazing	Trefoil and orchard grass Grazing	Alfalfa Soiling	Trefoil and orchard grass Soiling	Alfalfa Grazing	Trefoil and orchard grass Grazing
No. of animals	10	10	10[b]	10	20	20	20	20
Days on experiment	108	108	108	108	108	108	108	108
Initial wt., lb.	645	629	660	666	71	69	66	73
Av. daily gain, lb.	1.50	1.76	1.66	1.75	0.21	0.24	0.34[a]	0.31[a]
Feed consumption per head per day as fed								
Green forage, lb.	76.8	102.4			11.2	14.4		
Sudan Grass hay, lb.	3.5	3.0	5.1	3.2	0.98	0.62	0.12	0.10
Dry basis								
Green forage, lb.	18.3	17.7			2.3	2.4		
Sudan Grass hay. lb.	3.2	2.7	4.6	2.8	0.89	0.56	0.10	0.09
Dry matter per 100 lb. gain	1431	1158			1501	1252		

[a] Significant at the 1% level when compared to soiling for sheep.
[b] One steer lost due to bloat.

TABLE 2. MEAT PRODUCTION PER ACRE IN 108 DAYS (LB.)

		Alfalfa forage	Trefoil and orchard grass forage	Mean	Over-all Mean
Steers	Pasture lots	447	359	403	
	Soilage lots	563	444	504	
	Mean	505	402		453
Sheep	Pasture lots	440	388	414	
	Soilage lots	463	417	440	
	Mean	452	402		427
	Over-all Mean	478[a]	402		
Average, pasture lots		408			
Average, soilage lots		472[b]			

[a] Statistically significant difference from feeding trefoil-orchard grass forage.
[b] Statistically significant difference from pasturing.

consuming trefoil-orchard grass attained a choice slaughter grade in fewer days than the corresponding lambs fed alfalfa.

The overall average daily gain of the animals used for fecal collection follows closely that of all animals in the respective lots for the complete 108-day experiment (table 3). The chromic oxide "grab" sample technique did not influence the weight gains of the steers during the time the collec-

TABLE 3. RESULTS FROM ANIMALS ON COLLECTION

	Dry lots [a]		Pasture lots	
Steers	Alfalfa soiling	Trefoil and orchard grass soiling	Alfalfa grazing	Trefoil and orchard grass grazing
No. of steers	3	3	3	3
Av. daily gain, lb.[a]	1.34	1.73	1.65	1.66
Feed consumption daily, dry basis	Calc.	Calc.	Calc.	Calc.
Green Forage, lb.	19.77	18.35	14.59	18.98
Sudan Grass hay, lb.	3.2	2.6	4.6	2.5
Feed per 100 lb. gain, lb.[a]	1737	1197	1183	1296
	1712	1210	1180	1291
Sheep				
No. of sheep	5	5	5	5
Av. daily gain, lb.[a]	0.16	0.23	0.32[b]	0.30[b]
Feed consumption daily, dry basis	Calc.	Calc.	Calc.	Calc.
Green Forage, lb.	1.42	1.85	2.36	2.70
Sudan Grass hay, lb.	0.88	0.56	0.14	0.11
Feed per 100 lb. gain, lb.[a]	1499	1062	788	913

[a] The average daily gain is the gain for the collection animals during the 108-day experiment. It was assumed that the daily feed consumed by the collection animals during collection periods was representative of the consumption for the 108-day period. This calculated total feed consumed and total gain were used to calculate feed per 100 lb. gain.
[b] Significant at 1% level when compared to soiling for sheep.

tions took place. This is in contrast to that found with fecal collections by fecal collection harnesses as reported by Meyer *et al.* (1956). There was a loss of weight by the sheep wearing fecal collection harnesses during the time when this collection took place but the sheep gained very rapidly during the period following fecal collections and made up for the loss in weight caused by wearing collection bags and harnesses.

The daily feed consumption of the collection steers given alfalfa pasture was highly significantly less than that of the steers fed alfalfa soilage. There was a statistically significant difference in forage consumption for the sheep because the sheep given pasture consumed more than the sheep given soilage.

Discussion

When these experiments were designed, the authors considered that type of plant species and animal species might have an influence on production from soilage or pasture. The results produced indicate the greater increase in production expected from soiling a tall, sparse growing forage as alfalfa compared to soiling a short dense forage such as the trefoil-orchard grass did not materialize. The alfalfa in this study ranged in height from 32 to 45 inches while the trefoil-orchard grass varied between 10 and 16 inches. The trefoil-orchard grass pasture was a denser stand than the alfalfa. Dry matter yield of the trefoil-orchard grass in this study was 60% that of alfalfa. Beef production from soiling alfalfa and trefoil-orchard grass forage was 26 and 24% greater than pasturing these same respective crops. The increases in lamb production per acre were 5 and 7.5%, respectively. It should not be concluded that type of forage should not be considered in planning a soiling operation because certainly differences exist in costs of harvesting which were not measured in this study.

The small increase in production from soiling for lambs seems to indicate that even with labor saving machines such as the self-unloading wagon and field forage harvester, soilage would not appear promising. Since the lambs on pasture fattened more rapidly, even more would be realized from pasturing rather than from feeding soilage to lambs.

Soilage for steers seems to have economical possibilities under some conditions. The increase in beef production from soilage compared to pasture was 26% for alfalfa while previous work from this station showed in one report a 69% increase (Ittner *et al.*, 1954) while 29 and 57% were observed in a later report (Meyer *et al.*, 1956).

Another interaction for plant species and method of harvesting was revealed in the efficiency of feed utilization. A statistically highly significant interaction of plant species (alfalfa or trefoil-orchard grass) and method of feeding (soilage or pasture) was found when the amount of feed per 100 lb. of gain was analyzed. An inspection of the data showed that greater increase in efficiency of feed utilization occurred when alfalfa

was pastured rather than soiled. Feed utilization did not increase to the same extent when the trefoil-orchard grass was pastured rather than soiled.

One important aspect of this study was to compare the response of cattle and sheep to the various treatments. A difference was noted in daily gains because the steers made approximately the same gains on soilage and pasture while the sheep showed a highly significant increase in daily gains when pastured rather than fed soilage. On the other hand, the steers given trefoil-orchard grass forage either as soilage or pasture gained significantly faster than the steers given alfalfa. This was not true for the sheep.

For feed consumption by the steers, however, a highly significant interaction was present for method of feeding versus kind of forage. An inspection of the data revealed that feed consumption of the steers given alfalfa pasture was much lower than that of the other lots. This was also noted by Meyer *et al.* (1956). Therefore, it seems that feed consumption of steers on pasture is influenced by the kinds of forage offered. This was not noted with the sheep.

Differences were noted between the sheep and cattle in regards to bloat. Of course, no bloat occurred with either sheep or cattle given the trefoil-orchard grass forage. No difference in incidence of bloat occurred between sheep and cattle fed alfalfa soilage. However, many cases of bloat occurred in the steers grazing alfalfa; some needed treatment; and one steer died from bloat. Special precautions were needed for the steers such as having them consume dry hay before grazing and limiting grazing time the first two days a new pasture was entered. The authors were very concerned when the alfalfa pasture sheep refused to consume dry Sudan hay and in addition the sheep added to the tension by immediately selecting the leaves and fine stems for food. Their sides became distended but the sheep did not appear uncomfortable. No problem of bloat sufficiently severe to require treatment existed during this trial for any sheep.

It should be pointed out that stocking rate (number of sheep or steers grazed per acre) did not influence comparisons between sheep and steers in meat production per acre. Moveable fences were used to control the size of the area pastured so that each pasture was grazed at the same intensity. Areas grazed were harvested at the end of each grazing period. This refused forage was weighed and samples taken for dry matter determinations. The forage refused by the sheep amounted to 637 lb. per acre while it was 652 lb. per acre for the steers. There was no statistical differences between these figures. This indicates that equivalent degrees of grazing intensity or stocking rate was obtained.

In general it appears that sheep were superior to steers in their ability to utilize pasture. This was borne out by daily gains, feed consumption, efficiency of feed utilization and type of gain on pasture. On the other hand, steers did exceed sheep in the utilization of alfalfa soilage when meat production per acre is considered.

Summary

A factorially designed experiment was conducted to compare the gains and feed utilization of sheep or cattle when fed alfalfa or trefoil-orchard grass forage either as soilage or pasture. Sheep given either forage as pasture made a faster rate of gain than those fed soilage. Little difference existed in feed consumption among the sheep treatments. Consequently the forage consumed from pasture by the sheep was much more efficiently used for weight gains. In addition the sheep on pasture fattened more rapidly than either the sheep fed soilage or the steers given soilage or pasture.

The steers fed soilage or pasture, however, made about the same weight gains. Greater gains were made by the steers fed trefoil-orchard grass either as soilage or pasture than by the steers given alfalfa. Feed consumption by the steers grazing alfalfa was lower than the feed consumption of the steers fed alfalfa soilage. This difference was not noted between the steer treatments fed trefoil-orchard grass forage. Meat production per acre between sheep and steers was not significantly different except for the animals fed alfalfa soilage.

In general as measured by rate of gain, type of gain and efficiency of feed utilization, it was concluded that under these conditions sheep utilize pasture more efficiently than do steers. However, steers did utilize alfalfa soilage more efficiently when meat production per acre was considered.

Soiling of either crop for sheep produced about 6% more meat per acre than pasturing these forages. Beef production per acre from soiling was approximately 25% greater than that from pasturing either forage. The relative increase from soiling for both sheep and cattle was the same for alfalfa or trefoil-orchard grass. It was concluded from these data that soiling a tall forage would not produce relatively more meat per acre than soiling a short, dense forage when soiling is compared to pasturing.

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SELECTIVE GRAZING BY SHEEP AND CATTLE

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IT is well recognized that offering forage in the form of pasture to cattle and sheep gives them the opportunity of selecting a diet with a different composition than would be consumed from hay or soilage. A report from this station (Lofgreen and Meyer, 1956) showed a small but consistent increase in TDN due to selective grazing and also suggested that selective grazing may be more pronounced with mature than with immature forage. Furthermore, data were presented indicating that the net energy of the TDN in forage selected by grazing steers may be greater than that of the TDN in harvested fresh forage or hay made from the same crop (Lofgreen *et al.*, 1956). Earlier Hardison *et al.*, (1954) reported the first quantative results showing the degree of selection by grazing cattle. They also adequately reviewed previous work on selective grazing which had largely been studied with qualitative tests.

A companion paper (Hull *et al.*, 1957) reports that sheep were superior to cattle in utilization of pasture when daily gains, efficiency of feed utilization and type of gain were considered. However, steers made better use of alfalfa soilage. Results from this study also indicated that soiling a tall forage such as alfalfa was relatively no more productive than soiling a short denser forage (trefoil-orchard grass). It is the purpose of this paper to show that many of the variations between sheep and cattle in utilization of forage is due to differences in abilities between sheep and cattle to select forage. Digestibility, forage consumption, total digestible nutrient consumption, weight gains and yield of dry matter and total digestible nutrients were used as criteria to assess the importance of selective grazing.

Experimental

Forty head of good to choice Aberdeen Angus feeder steers were randomly divided into four lots of ten head each. One lot was assigned to each of the following treatments: six-day rotational grazing of alfalfa; soiling of alfalfa; six-day rotational grazing of trefoil-orchard grass forage; and soiling of trefoil-orchard grass forage. Eighty head of good to choice feeder sheep were randomly divided into four lots of 20 head each and the lots assigned as noted above for the steers. Adjacent fields of alfalfa and trefoil-orchard grass forage were divided into six blocks and the treatments assigned to each block. The details and management procedure have been described in a previous report (Hull *et al.*, 1957).

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Blocks three and four were used for a detailed study of digestibility and consumption of the forage. Three trials were conducted since each block was grazed three times during the 108-day trial. Digestibility and forage consumption for the steers were measured by the chromogen-chromium oxide technique of Reid *et al.*, (1952). For the sheep the chromogen method was used for digestibility but fecal collection harnesses were used to measure quantative fecal excretion. The animals grazed for a 5-day preliminary period in block 3 and a six-day collection was made in block 4. Total digestible nutrient consumption was calculated by the method described by Lofgreen and Meyer (1956). Due to the contamination by dust from the roads and soil picked up by the forage harvestor, silica was determined on all samples. Calculations were made on a silica-free basis.

Data on the dry matter available to the pastured animals were obtained by clipping ten 3-square-foot areas per 0.4 acres. This was done every six days before the animals entered their new pasture. Accurate records were kept on the dry weight of the soilage harvested and areas used. These data made it possible to calculate the efficiency of nutrient and dry matter utilization as influenced by selective grazing.

Results and Discussion

The total digestible nutrient content of the forage consumed (table 1) reveals some interesting differences between the selective grazing ability of sheep and cattle. When either alfalfa or trefoil-orchard grass forage was fed as soilage, there was no difference in the TDN content of the forage consumed by either sheep or cattle. Here there was little opportunity for selection.

The TDN content of the trefoil-orchard pasture consumed by sheep and cattle was the same. However, the sheep did select from alfalfa pasture a diet which had a higher TDN content that that selected from the alfalfa pasture by steers. The interaction of animal species and method of feeding was statistically significant. An important degree of selection was exhibited, however, by the steers on alfalfa pasture as evidenced by the 60.7% TDN compared to 56.6% TDN in alfalfa soilage.

TABLE 1. TOTAL DIGESTIBLE NUTRIENT CONTENT OF FORAGE CONSUMED (DRY MATTER BASIS)

		Alfalfa	Trefoil-orchard grass
		%	%
Steers	Soilage	56.5	66.0
	Pasture	60.7	66.4
Sheep	Soilage	58.0	64.5
	Pasture	66.1	67.4

Superior selective grazing ability of the sheep compared to the steers is also demonstrated in figures 1 and 2. Figure 1 shows the aftermath from the steer alfalfa pasture which exhibits more leaves unconsumed than shown in the aftermath left by sheep (figure 2). It was very apparent to the authors throughout the trial that very few leaves were missed during grazing by the sheep whereas the steers did not seem to attempt to select as many leaves.

Another point showing that sheep did more selecting than cattle is that the amount of dry matter consumed from one acre in all treatments by the sheep was much less than by the steers (table 2). The sheep grazing the

TABLE 2. CONSUMPTION OF FORAGE DRY MATTER AND TOTAL DIGESTIBLE NUTRIENTS [a]

	Steers			Sheep		
	Dry matter available	Dry matter consumed	TDN consumed	Dry matter available	Dry matter consumed	TDN consumed
Alfalfa lb. per A.						
Soilage	2688	2460	1387	2688	2074	1203
Pasture	2711	1612	978	2691	1252	832
Trefoil-Orchard Grass lb. per A.						
Soilage	1562	1517	999	1562	1470	973
Pasture	1567	1389	921	1437	1345	906

[a] Average consumption during three collection periods.

alfalfa pasture in particular, consumed less dry matter per acre than did the steers. The increased TDN content of the alfalfa forage selected by the sheep was not enough, however, to compensate completely for the lowered dry matter intake. The sheep, therefore, consumed less TDN than the steers from alfalfa pasture. However, they produced as much meat per acre as did the steers. The data of Hull *et al.* (1957) also shows that the sheep made a fattening gain while the steers did not. Even though the gain of the sheep probably contained more energy because of their finished condition, more meat was produced per 100 lb. of TDN consumed by sheep on alfalfa pasture than steers on the same treatment (table 3). In other words, the TDN selected by the sheep contained more net energy than the TDN selected by the steers. This emphasizes the suggestion by Lofgreen *et al.*, (1956) that measurement of pasture value needs to be on some basis which involves the net energy principle.

Actually the urge to select was a detriment to the sheep fed alfalfa soilage. The steers produced 563 lb. of meat per acre while the sheep produced 463 lb. (table 4). It was not possible to force the sheep to consume relatively the same amount of the alfalfa soilage as did the steers. It seems that

Figure 1. The refused alfalfa left after 6 days grazing by steers.

Figure 2. The refused alfalfa left after 6 days grazing by sheep.

TABLE 3. GAIN IN BODY WEIGHT PER 100 LB. OF TDN CONSUMED

		Alfalfa	Trefoil-orchard grass
		lb.	lb.
Steers	Soilage	10.4	12.8
	Pasture	14.3	11.9
Sheep	Soilage	11.7	15.1
	Pasture	19.3	16.4

the urge to select by sheep is so great that soilage feeding of alfalfa will not be as successful as has been found with steers. In fact sheepmen in California have not been successful with feeding alfalfa soilage while cattlemen have.

In terms of TDN content of the forage (table 1), TDN consumed per acre (table 2) and meat production per acre (table 4) little difference was noted between steers and sheep fed trefoil-orchard grass either as soilage or pasture. However, the sheep did produce more gain per 100 lb. of TDN consumed than did the steers (table 3). It is not apparent why the steers and sheep did not make the same gain per 100 lb. of TDN consumed from the soilage because ability to select was prevented by chopping the harvested forage. Selective grazing, however, might explain the greater gain by the sheep compared to the steers from the TDN in the trefoil-orchard grass pasture. At least it can be concluded that differences in ability to select between sheep and cattle were not manifested to the same degree with the trefoil-orchard grass as it was with alfalfa.

These data do not exclude the use of sheep as experimental animals for cattle fed harvested roughage. However, some doubt is cast on the use of data from one species to predict the response of the other grazing pasture or rangeland where selective grazing can be manifested.

TABLE 4. RELATIVE PRODUCTION FROM TREFOIL-ORCHARD GRASS AND ALFALFA FORAGE

	Yield per acre		Trefoil-orchard grass production, % of alfalfa
	Alfalfa	Trefoil-orchard grass	
	lb.	lb.	
Forage dry matter:			
Soilage	8425	5029	58
Steer pasture	8337	5268	63
Sheep pasture	8258	5024	61
Meat:			
Steer soilage	563	444	79
Steer pasture	447	359	80
Sheep soilage	463	417	90
Sheep pasture	440	388	88

In general the trefoil-orchard grass forage connsumed contained more TDN than the alfalfa forage (table 1). There was one exception. The sheep on alfalfa pasture did a superior job of selection and actually consumed an alfalfa forage with as high a TDN as that consumed from the trefoil-orchard pasture. The interaction of method of feeding and plant species was statistically highly significant which gives weight to this evidence. Also table 3 shows that the gain for the sheep per 100 lb. of TDN consumed from alfalfa pasture was larger than the gain by the sheep on trefoil-orchard grass pasture.

Selective grazing which resulted in refusals to eat coarse alfalfa stems together with the higher TDN of the trefoil-orchard grass tended to narrow the importance of differences in yield between alfalfa and trefoil-orchard grass. Table 4 shows that trefoil-orchard grass produced 58 to 63% of the dry matter produced by alfalfa. This is in line with extensive yield data of Peterson and Hagen (1953). The steers, however, produced 80% as much meat from one acre of trefoil-orchard grass as they did from alfalfa even though alfalfa produced a greater yield of dry matter. An even greater utilization was made by the sheep. The sheep produced 89% as much meat per acre from the trefoil-orchard grass as from the alfalfa.

Yield of forage dry matter, therefore, will not correctly appraise its value for animals. The final analysis will always have to be with the animal as the measuring unit. Even here a great deal of caution needs to be exercised because of differences in the composition of weight gains and possible influence of improper weighing conditions if the animals are not shrunk before weighing. It appears that forage consumption on pasture and digestibility data are necessary to correctly interpret results from pasture investigations. It may also be that body composition data will be needed in many experiments.

Summary

Studies were made of differences in ability of sheep and cattle to graze selectively alfalfa and trefoil-orchard grass forage. Criteria used to assess the importance of selective grazing were digestibility, forage consumption, total digestible nutrient consumption, weight gains, yields of dry matter and yields of total digestible nutrients. Differences between sheep and cattle were apparent when given alfalfa forage. The sheep selected and consumed from the alfalfa pasture a forage higher in total digestible nutrients and made more gain per unit of total digestible nutrients consumed than did the steers. With the trefoil-orchard grass, however, difference between sheep and cattle in ability to select were not as apparent. It appears that with a low dense forage selective grazing will not have as great an influence as it has with a tall, less dense forage.

The steers made better use of the alfalfa soilage because they consumed

more feed. The sheep were unable to select the forage desired and this seemed to interfere with feed consumption and hence production.

Selective grazing which resulted in refusals to eat the coarse alfalfa stems combined with higher total digestible nutrient content of trefoil-orchard grass forage decreased the importance of differences in dry matter yield between alfalfa and trefoil-orchard grass forage. Even though trefoil-orchard grass produced 58 to 63% the amount of dry matter produced by alfalfa, the ultimate yield in terms of beef and lamb produced per acre showed that trefoil-orchard grass yielded 80 and 89% respectively the yield from alfalfa.

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BEHAVIOR PATTERNS OF SHEEP AND CATTLE BEING FED PASTURE OR SOILAGE

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A KNOWLEDGE of the behavior of grazing animals is important to a complete understanding of productive performance. This is particularly true when data are also available on dietary intake and digestibility.

Although studies of grazing habits of cattle and of sheep have been made previously, the authors are familiar with no study comparing the behavior of these two species on the same type of forage at the same time when fed either as pasture or soilage.

The two companion papers (Hull *et al.*, 1957; Meyer *et al.*, 1957) report the results on forage utilization by the steers and sheep. It is the purpose of this paper to present the results of behavior studies carried on during these experiments and to correlate the behavior patterns with selective grazing, digestibility, and nutrient consumption and utilization.

Experimental

The layout of fields, handling of animals and the procedures used in measuring production and digestibility have been described in the two previous papers. A series of 24-hour observations was started at noon on the second day in a new field and terminated at noon on the third day. A second 24-hour observation was started at noon on the fifth day in the field and terminated at noon on the sixth. For convenience these two observations are referred to as the second and fifth day. Their purpose was to determine possible changes in behavior when animals are grazing abundant compared to scant forage. The size of the fields were adjusted so that forage would be well utilized at the end of six days. A second set of observations were made in the same manner described when the animals were moved to a new block. An example of the agreement between the two sets of observations is in table 1. The agreement was very close in all lots between observations I and II.

As many observations were made as possible during the 24 hours. For example, starting with the steers on alfalfa pasture the number of animals grazing, eating hay, standing ruminating, standing idling, lying ruminating, lying idling, drinking and licking salt was recorded. The observer then moved on to the sheep on alfalfa pasture, recorded the time and made the same observations. This procedure was repeated for steers on trefoil-

[1] The authors express their appreciation to Jim Clawson, Dick Craven and Allen Strother for assistance in making the observations.
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orchard grass pasture, sheep on trefoil-orchard grass pasture, steers on alfalfa soilage, sheep on alfalfa soilage, steers on trefoil-orchard grass soilage and sheep on trefoil-orchard grass soilage. The procedure was then repeated throughout the 24-hour period. During daylight hours a complete round could be made approximately every 20 minutes while at night the time required to make a round was approximately 30 minutes. After dark observations were made by use of a flashlight. It was found the steers were completely undisturbed by the light while at first care had to be exercised to prevent the sheep from becoming nervous. If there was any doubt as to the validity of the observation it was discarded. With a little experience and care, however, good observations were obtained on the sheep with no difficulty. Very few observations had to be discarded.

TABLE 1. COMPARISON OF TWO SETS OF OBSERVATIONS OF STEERS GRAZING ALFALFA PASTURE

	Day in field			
	Second		Fifth	
	Observation			
	I	II	I	II
	Time spent, hours			
Grazing	6.6	5.6	7.8	7.9
Eating hay	1.2	1.8	0.9	1.0
Ruminating	4.0	4.7	7.6	7.8
Idling	12.0	11.7	7.5	7.3
Drinking	0.2	0.2	0.2	0.0

In calculating the time spent during a 24-hour period in a given behavior it was assumed that the number of animals observed in a given behavior group continued in that behavior until the next observation. For example, if at 12:00 noon it was observed that four steers were grazing alfalfa pasture while six were ruminating and the next observation was made at 12:20 p.m. it was assumed that four steers grazed for 20 minutes and six ruminated for 20 minutes. It is recognized that such an assumption is not strictly valid. Because of the large number of individual observations made, however, it was felt that the error involved would be small. For the four 24-hour periods an average of 55 observations per lot were made for each 24 hours. Based on 10 steers and 20 sheep per lot this amounted to 550 observations of individual steers and 1100 for the sheep. A few animals changing their behavior between observations would thus result in a small error. The agreement between observations as shown in table 1 indicates that the technique is reproducable. If large errors were involved such good agreement probably could not have been achieved. The procedure used in these studies is similar to that described by Taylor (1953).

Results and Discussion

The average amount of time spent eating green forage, eating hay and ruminating in a 24-hour day is shown in table 2. Changes in the time spent

TABLE 2. BEHAVIOR PATTERNS OF STEERS EATING ALFALFA AND TREFOIL-ORCHARD GRASS FORAGE

	Eating Green forage		Eating hay		Ruminating	
	Steers	Sheep	Steers	Sheep	Steers	Sheep
Pasture						
Alfalfa						
Second day in field	6.1	6.9	1.5	0.2	4.4	3.1
Fifth day in field	7.9	10.1	1.0	0.2	7.7	3.4
Trefoil-Orchard Grass						
Second day in field	6.7	8.6	0.7	0.2	5.9	4.5
Fifth day in field	6.4	9.0	0.8	0.5	7.7	4.4
Soilage						
Alfalfa						
Second day in field	5.1	4.1	0.6	2.0	7.5	6.1
Fifth day in field	4.8	4.2	1.2	1.6	7.5	5.8
Trefoil-Orchard Grass						
Second day in field	4.0	4.5	1.2	0.4	6.1	5.9
Fifth day in field	4.4	4.2	0.7	0.6	6.9	6.1
LSD P=.01	1.3		0.7		1.1	
P=.05	0.9		0.5		0.8	

grazing or eating soilage and that spent ruminating are shown by hourly intervals in figure 1. Rumination time includes both standing and lying.

There are a number of interesting effects noticeable from these data. Both steers and sheep spent more time grazing on alfalfa pasture the fifth day in the field than they did on the second day. This is shown in figure 1 by the increase in the amount of time spent grazing per hour during grazing, and also in the case of the steers, the increase in the number of hours during which some animals were grazing. On trefoil-orchard grass pasture, however, there was no difference in grazing time between the second and fifth days. The difference in the grazing pattern of steers and sheep on alfalfa pasture is interesting. The periods of grazing were more definite with steers than with sheep. This is particularly noticeable on the second day where some sheep were grazing well into the night while only during one hour were there steers observed grazing after dark. As would be expected, the time spent eating soilage did not vary between the two days since the amount of forage available and its stage of maturity were the same. The difference between steers and sheep in the time spent ruminating is important. On both alfalfa and trefoil-orchard grass steers spent more time ruminating the fifth day than on the second. This is due to the increased time spent per hour although the time of day during which ruminating occurred did not change (figure 1). The sheep, however, rumi-

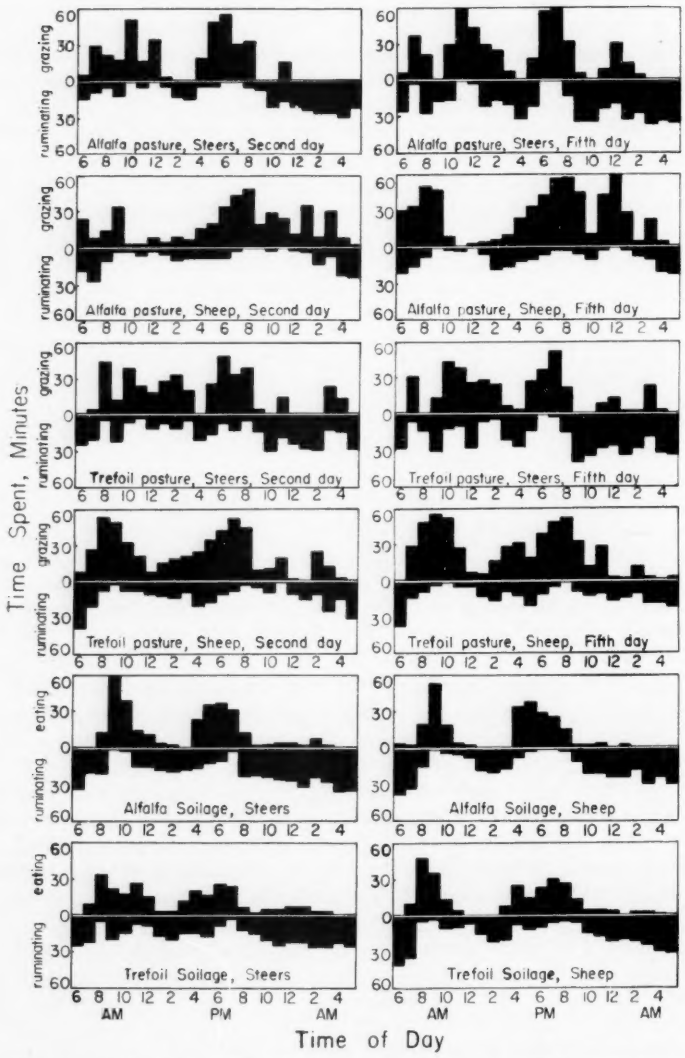
Time Spent, Minutes
grazing
ruminating
eating
Alfalfa pasture, Steers, Second day
Alfalfa pasture, Steers, Fifth day
Alfalfa pasture, Sheep, Second day
Alfalfa pasture, Sheep, Fifth day
Trefoil pasture, Steers, Second day
Trefoil pasture, Steers, Fifth day
Trefoil pasture, Sheep, Second day
Trefoil pasture, Sheep, Fifth day
Alfalfa Soilage, Steers
Alfalfa Soilage, Sheep
Trefoil Soilage, Steers
Trefoil Soilage, Sheep
6 8 10 12 2 4 6 8 10 12 2 4
AM PM AM
Time of Day

Figure 1. Behavior pattern of steers and sheep over a 24-hour period.

nated the same length of time each of the two days, and the pattern of time spent ruminating the two days was similar. Steers spent more time ruminating on both days than did the sheep. Hancock (1950) suggests that animals spend less time ruminating on high quality forage than on low quality. If this is true one must conclude that the sheep selected the more highly digestible portions of the forage available than did the steers. Even though it would appear to be more difficult to select on soilage the sheep spent significantly less time ruminating on alfalfa soilage than did the steers. On trefoil-orchard grass soilage the differences were much smaller. Indeed Meyer *et al.*, (1957) showed that sheep did select forage higher in TDN than did steers when pasturing these two types of forage.

Hancock (1950) further suggests the quality of forage affects the ratio of ruminating time (RT) to eating time (ET). Table 3 presents the rela-

TABLE 3. RELATIONSHIP OF DIGESTIBILITY TO THE RATIO OF RUMINATING TIME (RT) TO EATING TIME (ET)

		Alfalfa		Trefoil-orchard grass	
		TDN %	RT/ET	TDN %	RT/ET
Steers	Soilage	56.5	1.52	66.0	1.55
	Pasture	60.7	0.85	66.4	1.04
Sheep	Soilage	58.0	1.44	64.5	1.38
	Pasture	66.1	0.40	67.4	0.51

tionship of RT/ET to digestibility. It will be noted that as digestibility increases the animals spend a relatively smaller proportion of their time ruminating in comparison to eating.

When RT/ET is plotted against TDN a difference is noted between alfalfa and trefoil-orchard grass (figure 2). These data show that with alfalfa there is a marked change in RT/ET with changes in the TDN content of the forage being selected. This is in agreement with the studies of Wardrop (1953) who reported that cud-chewing in dairy cows was correlated with a low moisture and a high fiber in the herbage being consumed. When steers or sheep were consuming trefoil-orchard grass, however, there did not appear to be such a close relationship between the RT/ET ratio and TDN. It is felt this is a reflection of the ability of steers and sheep to graze alfalfa with a high degree of selectivity while their ability to select trefoil-orchard grass is much less as shown by the small variation in TDN.

Since the TDN content of the forages as determined is a measure of the average digestibility of the forage over a given six-day period it is not possible to compare directly the digestibility of the diet selected on the second day to that selected on the fifth day. Because of the close relation-

ship, however, of the RT/ET ratio to TDN of alfalfa forage an opportunity is provided to estimate the changes in TDN of alfalfa forage selected on the second and fifth days on a pasture. By use of the regression equation Y=8.3—0.12X and the RT/ET ratios shown in table 4 it is possible

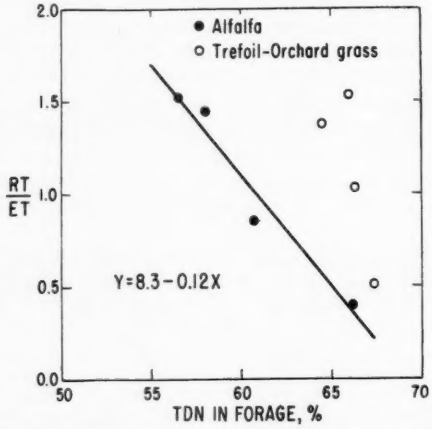

Figure 2. Relationship of RT/ET to TDN in the diet selected.

to calculate the TDN content of alfalfa forage on the second and fifth days in the field. From the ratios of 0.72 and 0.97 for steers on alfalfa pasture it is estimated that they consumed a forage containing 63.3 and 60.8% TDN on the second and fifth days respectively. The sheep, on the other hand, showed little difference in the RT/ET ratio between the second and fifth days on either alfalfa or trefoil-orchard grass pasture. It can be concluded, therefore, that even on the fifth day in the field the sheep were able to select forage of high digestibility while the steers were not able to maintain their ability to select to the same extent on the fifth day as on the second. The ratios shown for soilage indicate, as would be expected, no difference in forage quality between the second and fifth days. They further indicate as shown by Meyer *et al.* (1957) that the soiling prevented the same degree of selection which was shown on pasture.

It is interesting to compare the amount of time spent eating by the various lots to the consumption of dry matter and TDN. Such a comparison is shown in table 5. It is noted that steers on pasture spent approximately two hours more per day grazing the pasture than eating soilage. This might be expected because of the time required to selectively graze. It is interesting, however, that despite the two hours longer time spent grazing the steers on alfalfa pasture consumed less dry matter and TDN than those on soilage. This confirms earlier work from this station (Meyer *et al.*,

TABLE 4. RATIO OF RUMINATING TIME TO EATING TIME THE SECOND AND FIFTH DAYS IN A FIELD

	RT/ET	
	Steers	Sheep
Pasture:		
Alfalfa:		
Second day	0.72	0.45
Fifth day	0.97	0.34
Trefoil-orchard grass:		
Second day	0.88	0.52
Fifth day	1.20	0.49
Soilage:		
Alfalfa:		
Second day	1.47	1.49
Fifth day	1.56	1.38
Trefoil-orchard grass:		
Second day	1.52	1.31
Fifth day	1.57	1.45

1956). The TDN which these steers were able to select by spending the two extra hours, however, produced as rapid a rate of gain and a higher efficiency of conversion of TDN to gain than did that consumed by steers on soilage (Hull *et al.*, 1957; Meyer *et al.*, 1957). The steers on trefoil-orchard grass pasture were able to consume as much dry matter and TDN as those fed soilage, but in this case the extra 2.4 hours spent resulted in the same rate of gain and same efficiency of conversion. It is interesting that in the alfalfa pasture two extra hours of eating time permitted the steers to select a TDN content higher in net energy than that of soilage while with trefoil-orchard grass the extra time spent did not have this effect. This again points out the greater ease of selective grazing a tall, rank growing forage such as alfalfa compared to a lower growing, denser forage such as trefoil-orchard grass mixture.

The sheep data are somewhat different in that those on pasture spent

TABLE 5. RELATIONSHIP OF DRY MATTER AND TDN COMSUMPTION TO TIME SPENT EATING

		Alfalfa			Trefoil-orchard grass		
		Dry matter consumed	TDN consumed	Eating time	Dry matter consumed	TDN consumed	Eating time
		lb.	lb.	hr.	lb.	lb.	hr.
Steers	Soilage	19.8	11.2	5.0	18.4	12.1	4.2
	Pasture	14.6	8.9	7.0	19.0	12.6	6.6
Sheep	Soilage	1.42	0.82	4.2	1.85	1.19	4.4
	Pasture	2.36	1.56	8.5	2.70	1.82	8.8

twice as much time (approximately four more hours) eating as those fed soilage. In the case of those on alfalfa the extra time spent eating on pasture resulted in a much greater dry matter and TDN consumption. This resulted in a significantly greater gain (Hull *et al.*, 1957) and a greater efficiency of conversion of TDN to gain in weight (Meyer *et al.*, 1957). The extra time spent grazing trefoil-orchard grass also resulted in a greater consumption of dry matter and TDN, but as was the case with the steers, the TDN was not utilized any more efficiently than that of the soilage. Thus with both steers and sheep the extra time spent grazing alfalfa pasture results in the consumption of TDN having a higher net energy content than those eating the same forage as soilage. This effect, however, is not observed with steers or sheep grazing trefoil-orchard grass.

Summary

Observations of behavior patterns of steers and sheep were made while on alfalfa pasture or soilage or on trefoil-orchard grass pasture or soilage.

Both steers and sheep spent significantly more time grazing alfalfa pasture on the fifth day in the field than on the second. The steers also spent more time ruminating on the fifth day while the sheep did not. Evidence is presented indicating that the ratio of ruminating time to eating time is affected by the TDN content of the forage being selected. On a highly digestible diet the animal spends proportionally less time ruminating than on one of lower digestibility.

On trefoil-orchard grass pasture the same length of time was spent grazing on the second and fifth days in the field. The difference in behavior pattern on the two types of forage seems to be related to the ability of the animal to graze selectively.

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CELLULOLYTIC INTERRELATIONSHIPS OF CARBOHYDRATES, FAT AND TRACE MINERALS IN SHEEP RATIONS [1]

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BENEFICIAL effects of alfalfa ash on *in vitro* cellulose digestion by rumen microorganisms were observed by Burroughs *et al.* (1950). Similar effects of alfalfa ash on the digestion of crude fiber in sheep rations which contained from 45 to 60% corn cobs have been reported by Swift *et al.* (1951) and Chappel *et al.* (1955). Workers at the Kentucky Agricultural Experiment Station (Thompson and Grainger, 1955; Summers *et al.*, 1956) observed that the digestibility of crude fiber was not improved by addition of alfalfa ash to sheep rations which contained 77 to 80% corn cobs.

Relatively high levels of readily available carbohydrates decreased crude fiber digestibility of ruminant rations in experiments reported by Hamilton (1942) and Fontenont *et al.* (1955). Swift *et al.* (1947) observed that low levels of dietary fat (3.6%) improved the apparent digestibility of sheep rations which contained alfalfa hay, whereas a higher level of fat (7%) had the reverse effect. Brooks *et al.* (1954) reported that the presence of alfalfa ash in combination with supplemental fat in sheep rations alleviated the depressing effect of the fat on cellulose and protein digestibility.

The experiments reported herein were designed to investigate the cause of variation in results reported by various workers. Likewise, these experiments were designed to study the effect on digestibility of interrelationships between carbohydrates, fats and minerals.

Experimental

This series of balance trials involved 24 crossbred wethers which weighed about 80 lb. each. These wethers were treated for internal parasites with phenothiazine and sheared before the beginning of the first trial. Four wethers were randomly assigned to each treatment in all trials. During the period between trials (30 days) the wethers were fed alfalfa hay *ad libitum*. The semi-purified basal rations and their calculated chemical composition are presented in table 1. The corn cobs were purchased locally, ground in a hammer mill through a one-half inch screen, mixed in a large commercial feed mixer and stored in burlap bags until needed. The alfalfa ash was prepared by burning alfalfa hay (U.S. No. 1) in bottomless metal

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barrels supported over collection tubs. The residue was cooled, passed through a fine mesh screen and stored in cardboard containers. This alfalfa residue, referred to in this paper as ash, was 98% ash (600° C.). In trial 1 the concentrate portion of the rations was mixed at the beginning of the trial and added to the roughage each time the wethers were fed. In the later trials all ingredients of each ration were mixed together. Distilled water was furnished in stone crocks to the wethers in each of the 3 trials.

The organic matter intakes of the wethers were equal on all rations within each trial. In formulation of the experimental rations corn oil (Mazola) replaced an equal weight of corn syrup (21 and 14 gm. daily

TABLE 1. BASAL RATIONS AND THEIR CALCULATED CHEMICAL COMPOSITION

Items	Daily ration per wether	
	I	II
Ration constituents, gm.		
Corn cobs	560.0	455.0
Drackett protein	42.3	42.3
Urea	8.4	8.4
Corn syrup	56.0	49.0
Corn starch	18.4	130.4
Vitamin and mineral additions [a]	14.9	14.9
Dry matter, %	92.9	93.2
Composition of dry matter, %		
Organic matter	95.8	96.7
Crude protein	11.3	10.6
Ether extract	0.3	0.3
Crude cellulose	44.5	37.7
Ash	4.2	3.3

[a] The daily ration of each wether contained: iodized salt, 3.5 gm.; calcium m-diorthophosphate, 9.6; magnesium sulfate, 1.5; elemental sulfur, 0.1; vitamin A and D concentrate, 0.2. This vitamin A and D concentrate provided 10,000 I.U. of vitamin A and 500 I.U. of vitamin D per gram.

in trials 1 and 2, respectively). Corn starch (105 gm. daily) was substituted for an equal weight of corn cobs in trial 1. The rations which contained alfalfa ash or the trace mineral mixture fed at levels to provide 30 gm. of alfalfa ash or 1.3 gm. of trace mineral mixture per wether each day. The composition of the trace mineral mixture (U.S.P. Chemicals) was: ferric citrate, 71 gm.; cupric sulfate, 2.6; cobalt sulfate, 0.0095; manganous sulfate, 3.3; zinc sulfate, 2.8; sodium molybdate, 1.8; and boric acid, 4.77. Elemental sulfur was omitted when the equivalent sulfate of the trace mineral mixture was included in the ration.

The wethers in this series of trials were stanchioned in metabolism cages similar to those described by Briggs and Gallup (1949). These trials consisted of a ration-adjustment period followed by a 10-day preliminary period, and a 10-day collection period. The metabolism laboratory was maintained at a temperature of 65–75° F. and other environmental factors

such as light and management were controlled for all trials. The collection, aliquotation and preparation of fecal and urinary samples for laboratory analyses were conducted by the method described by Woods (1956). The chemical analyses for nitrogen in urine and ether extract, dry matter, crude protein (nitrogen×6.25) and ash for the ration constituents and the feces were conducted by the methods of the Association of Official Agricultural Chemists (1950). The determination of crude cellulose hereafter referred to as cellulose was conducted by the method described by Matrone *et al.* (1946). The statistical analysis (analysis of variance and non-orthogonal comparisons) were conducted according to the methods of Snedecor (1950).

Results and Discussion

The mean apparent digestion coefficients hereafter referred to as digestion coefficients for cellulose, organic matter and crude protein and the mean daily nitrogen retention of the wethers are shown in table 2. In trial 1 the digestibility of cellulose and organic matter of the rations which contained 80% corn cobs was not affected by the inclusion of alfalfa ash or a combination of alfalfa ash and 3% corn oil in the rations. The replacement of 15% corn cobs with a equivalent amount of corn starch resulted in a 7.8% decrease in the digestibility of cellulose. This increased intake of readily available carbohydrate did not significantly affect the digestibility of the organic matter of the ration. Alfalfa ash or a combination of alfalfa ash and 3% corn oil included in the rations which contained 65% corn cobs increased the digestibility of cellulose by 10.2 and 9.6% respectively. Likewise, the digestibility of organic matter was significantly improved by alfalfa ash or the combination of alfalfa ash and 3% corn oil. Thus it appears that a higher intake of corn starch increases the inorganic requirements of the rumen microorganisms for optimum cellulolytic activity. The daily nitrogen retention and digestibility of crude protein were not significantly affected by the treatments in trial 1.

The substitution of 2% corn oil into the basal ration (65% corn cobs) in trial 2 decreased the digestibility of cellulose, organic matter and crude protein by 15.5, 11.3 and 6.4%, respectively. The initial design of trial 2 was based on a 3% corn oil addition to the rations, however, it was necessary to reduce the corn oil to 2% in order to maintain feed consumption in the absence of alfalfa ash. The addition of alfalfa ash to the basal ration increased the digestibility of cellulose and organic matter by 12.4 and 6.2%, respectively. The addition of corn oil to the rations which contained alfalfa ash did not significantly affect the digestibility of ration components. Daily nitrogen rentention of the wethers was significantly higher from rations which contained alfalfa ash than from the non-ash rations. These results in daily nitrogen retention suggest a protein-sparing effect of the digested carbohydrates in those rations which contained alfalfa ash. The

results of trial 2 are in agreement with those reported by Brooks *et al.* (1954) for rations in which cottonseed hulls was the roughage. Thus it is evidenced that both readily available carbohydrate (corn starch) and fat (corn oil) increase the mineral requirements of rumen microorganisms for cellulolytic activity.

The trace mineral mixture, which was patterned after the minor element composition of alfalfa (Schrenk and Silker, 1950), was as effective as alfalfa ash for promoting optimum cellulose digestion by the wethers in

TABLE 2. MEAN DAILY NITROGEN RETENTION AND APPARENT DIGESTION COEFFICIENTS

Treatment [a]	Crude cellulose	Organic matter	Crude protein	Daily nitrogen retention
				gm.
		Trial 1		
Basal I	74.2	65.9	68.6	0.75
AA	73.1	65.9	63.8	0.60
AA+CO	74.2	67.0	66.6	0.50
CS	68.4*	68.7	66.1	0.90
CS+AA	75.4	72.7*	67.0	1.30
CS+AA+CO	75.0	71.3*	68.0	1.20
		Trial 2		
Basal II	66.8	68.8	68.4	1.10
AA	75.1**	73.1**	69.3	2.40*
CO	56.4**	61.0**	64.0*	1.00
AA+CO	75.4**	71.0**	69.5	2.70**
		Trial 3		
Basal II	74.6	68.9	67.9	1.30
AA	78.0**	73.2**	68.6	1.50
TM	77.3**	73.0**	71.0	1.00

[a] Abbreviations: Alfalfa ash, AA; Corn oil, CO; Corn starch, CS and Trace minerals, TM.
* Significant at $P<.05$; ** Significant at $P<.01$.

trial 3. These results suggest that the decrease in cellulose digestion in the presence of relatively high intakes of readily available carbohydrate (corn starch) is due to a deficiency of minor minerals rather than a preference of the microorganisms for the corn starch.

Neiman (1954) stated that certain fatty acids inhibit the growth of microoragnisms. Bentley *et al.* (1956) observed that 9- and 10-carbon fatty acids depressed cellulose digestion in the artificial rumen whereas 5- and 6-carbon fatty acids had a stimulating effect. The decrease in cellulose digestion observed in trial 2 attributed to the presence of corn oil in the ration in indicative of disturbed rumen microbial processes. The mode of action of this inhibition or its reversal by alfalfa ash is not evident in these data. The significant depression of the digestibility of protein re-

sulting from the presence of corn oil in the ration may be due either to an increase in metabolic fecal nitrogen or an increase in exogenous fecal nitrogen. Since nitrogen retention was not affected by the difference in protein digestibility it is evident that urinary nitrogen was reduced when corn oil was present in the ration. Thus it appears that less protein was absorbed from the digestive tract and/or the absorbed nitrogen was metabolized more efficiently. It is interesting to note that the rations used by Brooks *et al.* (1954) contained only preformed protein whereas those reported herein contained both urea and preformed protein. Results of other experiments (Rhodes *et al.*, 1956) and the comparison with the findings of Brooks *et al.* (1954) show that the depressing effect of corn oil on protein digestibility is not related to source of nitrogen or protein.

In rumen bacterial studies Gall *et al.* (1949) observed a higher number of fast-growing bacteria in the rumen contents of cattle and sheep fed high-grain rations as compared to similar animals fed low-grain rations. These workers observed as many, or more slow-growing organisms in rumen contents from animals fed low-grain rations, Gall and co-workers suggested that the fast-growing bacteria utilize starch and the slower growing bacteria may be cellulose-digestors. It can be postulated that the effect of supplemental starch in the experiments reported herein was similar to the effect of grain on the rumen population studied by Gall *et al.* (1949). If so it is evident that an increase in microbial mineral requirements parallels the increase in number of fast-growing bacteria in the rumen population. Thus trace mineral fortification of high-starch rations is effective in maintaining the concentration of these elements in the rumen necessary for normal activity of the cellulose-digesting organisms.

Summary

A series of 3 balance trials was conducted with 24 crossbred wethers fed semi-purified rations which contained ground corn cobs as the sole roughage. Observations were made on the effects of an increased corn starch intake, an increased fat (corn oil) intake, supplemental alfalfa ash and trace minerals on daily nitrogen retention and the digestibility of cellulose, organic matter and crude protein.

The addition of alfalfa ash to a ration which contained 80% corn cobs did not affect the digestibility of cellulose, organic matter or crude protein. Increases in the corn starch content of the ration from 2.6 to 17.6% resulted in a significant decrease of the digestibility of cellulose. The substitution of 2% corn oil into a ration which contained 65% corn cobs significantly reduced the digestibility of cellulose, organic matter and crude protein. These depressions due to the presence of corn oil and corn starch in the rations were completely reversed by the addition of alfalfa ash to the rations. In some cases, daily nitrogen retention was significantly improved by the presence of alfalfa ash in the rations. A mixture of trace

minerals patterned after the minor element composition of alfalfa was as effective as alfalfa ash in supplying the minor minerals required by the rumen microorganisms for optimum cellulolytic activity with a ration which contained 65% corn cobs and 18.6% corn starch.

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SELF-FEEDING FREE CHOICE VS. SELF-FEEDING A COMPLETE MIXTURE FOR FATTENING STEERS [1]

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STANDARD practice in feeding fattening cattle under Corn Belt conditions, on a high concentrate ration in drylot is to feed the roughage and mineral mixture free choice and to hand-feed the grain and protein supplement—at least until the cattle have been brought up to a full-feed. Once the cattle are on a full-feed, the grain may be fed free choice and the protein supplement hand-fed. However, few cattle feeders will turn their cattle into a lot in which troughs filled with corn and supplement are available, the first day of the feeding period.

Furthermore, cattle feeders and nutritionists are in agreement that the protein supplement should not be fed free choice, because it is common belief that cattle would overeat of the protein supplement under such a management practice. Results of research reported by Archer *et al.* (1952), Riggs *et al.* (1953) and Nelson *et al.* (1953) have indicated the incorporation of salt would regulate the consumption of cottonseed meal to the extent that the mixture could be fed free choice, without any ill-effects on pregnant beef cows whose wintering rations required supplemental protein.

Geurin *et al.* (1955) reported that ground corn cobs could constitute the sole source of roughage in the fattening ration of cattle. The concept of feeding ground ear corn and a supplement—but no additional roughage —is relatively new in the field of beef cattle production.

A series of four trials was set up to obtain data on the following: (1) To compare the usual method of hand-feeding fattening cattle with the method of placing all the ingredients of the ration before the cattle on a free-choice basis; (2) To study the effect of self-feeding various rations of ground ear corn to protein supplement; (3) To study the effect of various levels of protein supplement for fattening cattle; (4) To study the effect of limiting the consumption of free choice protein supplement by the incorporation of salt; (5) To study the practice of utilizing the cob portion of ground ear corn as the sole source of roughage material for fattening cattle.

Experimental Procedure

Trial I. Sixty yearling Shorthorn steers averaging 742 lb. liveweight at the start were divided into two drylots to be fattened out. At the time of the start of the trial the cattle had been running on pasture where they had been receiving 6 lb. corn and 2 lb. Supplement A per head daily. The

[1] Contributed from the Department of Animal Husbandry, Journal Paper No. 1068.
[2] Trials I, II, and IV were conducted at Lynnwood Farm, Carmel, Indiana.

cattle assigned to the hand-fed lot were fed 3.50 lb. Purdue Supplement A per day, free choice mineral mixture composed of 2 bone meal to 1 of salt, plus loose salt free choice, and were brought up to a full feed of ground ear corn as rapidly as possible. Average quality mixed (grass-legume) hay was fed according to appetite. The cattle assigned to the self-fed lot had the same ingredients as listed above placed before them on a free choice basis, cafeteria-style, from the first day of the experiment. No materials were added to attempt to control the feed intake.

Trial II. Sixty yearling Shorthorn steers averaging 650 lb. liveweight at the start were divided into three drylots to be fattened out. The rations fed the three lots of steers were as follows:

	Full feed of ground ear corn	Purdue supplement A	Hay	2 bone meal 1 salt, plus loose salt
Lot I	Hand fed	2 lb., hand fed	free choice	free choice
Lot II	Hand fed	3.5 lb., hand fed	free choice	free choice
Lot III	Self fed (free choice)	Self fed (free choice)	free choice	free choice

The cattle in the self-fed lot (Lot III) were turned to bunks full of ground ear corn, Supplement A, hay and minerals, the first day of the trial and had access to all the ingredients of their ration at all times. The two hand-fed lots (Lots I and II) were fed twice per day and were brought up to a full feed of corn gradually.

Trial III. Sixty yearling Hereford steers averaging 634 lb. liveweight, were divided into 5 lots of 12 animals per lot.

Prior to the start of the experiment the cattle had received no grain or protein supplement, but had been fed hay and minerals. The first day of the experiment, the cattle were turned into their respective lots in which their troughs were filled with a complete mixed feed of ground ear corn and Purdue Supplement A in the ratios indicated: Lot I—4 parts ground ear corn to 1 part Supplement A; Lot II—6 parts ground ear corn to 1 part Supplement A; Lot III—8 parts ground ear corn to 1 part Supplement A; Lot IV—10 parts ground ear corn to 1 part Supplement A; Lot V—12 parts ground ear corn to 1 part Supplement A.

A free-choice mineral mixture of 2 parts steamed bone meal to 1 part salt fortified with cobalt sulfate (1 ounce per 100 lb. of salt) plus loose salt in another box was available at all times. During the first 28 days, mixed hay was available in all lots. However, approximately 2 lb. of hay per steer daily was all that was consumed during this period, so the feeding of hay was discontinued at the start of the second 28-day period.

Trial IV. Sixty yearling Shorthorns averaging 665 lb. liveweight were divided into four lots of 20 animals per lot. Four treatments were administered: Lot I—Self fed free choice ground ear corn, Supplement A, hay and minerals, in dry lot; Lot II—Same as Lot I except that the consumption

of Supplement A was regulated to slightly over 2 lb. per head daily by the incorporation of salt, in drylot; Lot III—Self fed a mixture of 8 parts ground ear corn to 1 part Supplement A, plus free choice hay and minerals, in drylot; Lot IV—Same as Lot III except that the cattle were fed their ration on a mixed grass and legume pasture, and also, there was no hay offered.

Results

Trial I. Data concerning growth rate, feed consumption, feed efficiency, and marketing and slaughtering performance are presented in table 1. The

TABLE 1. SELF-FEEDING VS. HAND-FEEDING FATTENING STEERS IN DRYLOT

July 2–October 8, 1954, 98 Days

	Lot 1 Hand-fed	Lot 2 Self-fed
	Weight data	
No. per lot	30	30
Ave. initial wt., lb.	740	744
Av. final wt., lb.	984	1008
Av. total gain, lb.	244	264
Av. daily gain, lb.	2.48	2.70*
	Daily feed consumption	
Ground ear corn, lb.	15.96	16.16
Supplement A,[a] lb.	3.50	5.43
Hay, lb.	9.45	4.98
Mineral, lb.	.04	.04
Total, lb.	28.95	26.61
	Feed per 100 lb. gain	
Ground ear corn, lb.	642.2	599.4
Supplement A, lb.	140.9	201.5
Hay, lb.	380.2	184.6
Mineral, lb.	1.4	1.2
Total	1164.7	986.7
T.D.N. per 100 lb. gain[b]	759.0	660.1
	Carcass data	
Lynnwood weight, lb.	984	1008
Market weight, lb.	933	963
Shrink, lb.	51	45
Shrink, %	5.2	4.4
Dressed weight, lb.	560	587
Dressing percent	60.0	61.1

[a] 1000 lb. mix: Soybean meal, 650.5 lb.; Molasses, 140.0 lb.; Alfalfa meal, 140.0 lb.; Bone meal, 52.0 lb.; Salt with cobalt, 17.0 lb.; Vit. A and D concentrate, 0.5 lb.

[b] T.D.N. calculation based on following: Ground ear corn, 73.2%; Supplement A, 66.2%; Hay, 50.9%

* Lot 2 gained significantly more than Lot 1 ($P<.05$).

self-feeding of steers resulted in significantly increased rate of gain, greater consumption of protein concentrates, 12% less total digestible nutrients per 100 lb. gain (based on average TDN figures), less shrink in transit to market, and slightly greater dressing percent.

Even though the self-fed cattle ate 55% more protein supplement than the hand-fed cattle, there was no undesirable effects such as scouring, or going off feed due to the intake of large amounts of supplement. On the

TABLE 2. A COMPARISON OF TWO LEVELS OF PROTEIN SUPPLEMENT WITH SELF-FED SUPPLEMENT FOR FATTENING CATTLE

(April 8–August 16, 1955, 130 Days)

	Lot I 2 lb. suppl. hand-fed	Lot II 3.5 lb. suppl. hand-fed	Lot III Self-fed free-choice
Number of steers	20	20	20
Initial wt., lb.	652	650	650
Final wt., lb.	957	954	986
Total gain, lb.	305	304	336
Daily gain, lb.	2.35	2.34	2.58**
	Feed Consumption, lb.		
Gr. ear corn	14.4	13.8	11.9
Supplement A	2.0	3.5	7.6
Hay	11.4	10.9	7.7
	Feed per 100 lb. Gain, lb.		
Gr. ear corn	612	589	462
Supplement A	85	149	292
Hay	287	464	297
	Market and Slaughter Performance		
Market wt., lb.	904	929	932
Dressed wt., lb.	548	564	584
Dressed mg. percent	60.6	60.7	62.7
	Federal Carcass Grade		
U. S. choice	18	20	20
U. S. good	2	—	—

** Lot III gained highly significantly more than Lot I and II ($P<.01$).

contrary, the self-fed cattle out-performed the hand-fed cattle in terms of (a) growth rate, (b) feed efficiency, (c) marketing shrink and dressing percent, (d) liveweight selling price, and (e) feed cost per 100 lb. gain. The carcasses from all 60 animals were graded "U. S. Choice" by the federal grader.

Trial II. Data concerning the performance of the cattle in Trial II are shown in table 2.

Hand-fed cattle fed 2.0 lb. of Purdue Supplement A gained just as rapidly and as efficiently as hand-fed cattle which were fed 3.5 lb. of

Supplement A. However, self-fed cattle gained 10% more rapidly than either of the hand-fed lots. Self-fed cattle dressed 2% higher at time of slaughter than either of the hand-fed lots. There was no real difference in carcass grades between the three lots.

Trial III. Growth rate, feed consumption, feed efficiency and carcass grades are presented in table 3.

TABLE 3. SELF-FEEDING VARIOUS RATIOS OF GROUND EAR CORN TO SUPPLEMENT A FOR FATTENING CATTLE

(November 8, 1955 to May 21, 1956, 195 days)

	Ratio of ground earn corn to supplement A				
	Lot I 4 Corn: 1 suppl.	Lot II 6 Corn: 1 suppl.	Lot III 8 Corn: 1 suppl.	Lot IV 10 Corn: 1 suppl.	Lot V 12 Corn: 1 suppl.
Number of steers	12	12	12	12	12
	Growth Data				
Wt., No. 8, lb.	633	637	630	636	636
Wt., May 21, lb.	1105	1143	1122	1111	1072
Total gain, lb.	472	506	492	475	436
Daily gain, lb.	2.42	2.60**	2.53**	2.44	2.24
% increase over Lot I	—	7.2	4.2	0.6	—7.6
	Daily Feed				
Gr. ear corn-Suppl. A., lb.	20.0	22.4	21.6	20.7	20.1
(Gr. ear corn lb.)	16.0	19.2	19.2	18.8	18.6
(Suppl. A., lb.)	4.0	3.2	2.4	1.9	1.5
	Feed per 100 lb. Gain				
Gr. ear corn-Suppl. A., lb.	824	862	853	850	897
(Gr. ear corn lb.)	659	739	758	773	828
(Supplement A., lb.)	165	123	95	77	69
	U. S. Carcass Grades				
U. S. prime	2	3	1	—	3
U. S. choice	10	8	11	12	7
U. S. good					2
Hot carcass wt., lb.	686	713	694	705	653
% increase over Lot I	—	3.9	1.1	2.8	—4.8

** Lots II and III gained highly significantly more than Lot V ($P<.01$).

Yearling steers gained satisfactorily on a ration which contained no roughage other than that contained in the cob portion of ground ear corn, (80% corn, 20% cobs) after the first 28 days when the diet was balanced with either one-seventh or one-ninth of the ration as Supplement A (Lots II and III). Hay was offered during the first 28 days, but an average of slightly less than 2 lb. per animal daily were consumed. *No hay was offered after the first 28 days.*

All animals were turned into their respective lots the first day of the trial with troughs full of their respective ratios of ground ear corn to supplement A. No attempt was made to control the intake of the rations at any time. All diets were self-fed.

Excessive looseness and scouring was observed in Lots IV and V during the first 7 to 10 days. Although the droppings in the other lots became noticeably thinner during this period, no excessive scouring was observed. Digestive disturbances are more acute and frequent when the ration is not balanced nutritionally. No ill effects were noted in cattle receiving a ratio of 8 parts ground ear corn to 1 of Supplement A (Lot III).

After an apparent adjustment period of from 7 to 10 days, the droppings appeared normal and no change was observed thereafter. The most rapid gains were made by the steers consuming either the 6:1 ratio or the 8:1 ration of ground ear corn to Supplement A. However, economy of gain was in favor of Lot III.

Growth rate, feed consumption, feed efficiency and carcass grades are presented in table 4.

Trial IV. There was no statistically significant difference in gain between the three lots of steers fattened in drylot. Thus, the following three methods of self-feeding cattle proved satisfactory and produced quite similar gains: (1) feeding ground ear corn, supplement and hay, free choice, (2) ground ear corn, free choice, supplement to which salt has been added (approximately 5%) and hay, free choice, (3) ground ear corn and supplement mixed together in a ratio of 8 parts ground ear corn to 1 part of supplement, and hay, free choice.

The level of salt necessary to control the intake of any given supplement may vary. During the first two weeks of this trial, 15% of added salt controlled the average daily intake of Supplement A to 0.66 lb. per steer (Supplement A contains an additional 1.7% of salt).

Cattle fed an 8:1 ratio of ground ear corn to supplement, on a self-fed basis, on pasture, did not gain as rapidly as the three lots of steers fed in drylot. The pasture available to the steers in Lot IV was quite lush and palatable and was reflected in a lowered consumption of concentrates.

Discussion

Cattle were successfully self-fed by three different methods, namely, (1) free choice of ground ear corn, Supplement A, hay and minerals, (2) mixing ground ear corn and supplement together in a ratio of 8 parts ground ear corn to 1 of Supplement A, and minerals, free choice, and (3) free choice of ground ear corn, Supplement A to which salt has been added to control the intake, hay and minerals. In three of these trials, the cattle had never received any corn prior to the time they were turned into their respective lots which contained bunks filled with concentrates.

Possibly the key factor which is necessary to be able to turn cattle to a

full-feed of concentrates the first day of the fattening period is the nutritional balancing effect of a good protein supplement. Some cattle feeders have had the impression that excessive amounts of protein would cause fattening cattle to scour. The reverse was true in the four trials reported in this paper. In fact, cattle self fed, free choice, which consumed an

TABLE 4. CONTROLLING THE INTAKE OF SUPPLEMENT WITH SALT

(April 19, to August 19, 1956, 122 Days)

	Ratio of ground ear corn to supplement A			
	Lot I self-fed	Lot II 5% salt in supp.	Lot III ratio 8:1 dry lot	Lot IV ratio 8:1 pasture
Number of steers	20	20	20	20
	Growth Data			
Wt., April 19, lb.	670	669	667	664
Wt., August 19, lb.	956	944	945	902
Total gain, lb.	286	275	278	238
Daily gain, lb.	2.34**	2.25**	2.28**	1.95
% increase over Lot I		3.8	2.6	
	Daily Feed			
Ground ear corn, lb.	17.07	17.87	19.31	13.89
Supplement A, lb.	4.40	2.20	2.41	1.74
Hay, lb.	3.54	4.24	3.44	—
	Feed per 100 lb. Gain			
Ground ear corn, lb.	730	794	848	711
Supplement A, lb.	188	98	106	89
Hay, lb.	151	188	151	—
	U. S. Carcass Grades			
Low prime			1	
High choice	20	18	17	13
Av. choice		2	2	7
Hot carcass wt., lb.	563	547	551	522
Dressing %	60.9	60.3	60.9	59.5

** Gained highly significantly more than Lot IV ($P<0.01$).

average of as much as 7.6 lb., 32% protein supplement showed no signs of scouring or of going off feed. On the other hand, when cattle were fed various ratios of ground ear corn to Supplement (Trial III) the only lots which showed marked looseness and scouring were those which received the least amount of protein supplement per head, daily. Pope *et al.* (1954) reported that fattening calves fed 1.5 lb. cottonseed cake per day grew more rapidly, more efficiently, and returned a greater profit than similar animals fed either 1.0 lb. or 0.5 lb. cottonseed cake per day. In all trials

in which supplement was fed free choice, cattle in these lots tended to gain more rapidly and to grade higher in the carcass than steers fed lower levels of protein supplement.

The incorporation of salt proved to be an efficient method of controlling the intake of free-choice protein supplement. The addition of 5% of salt controlled the average daily consumption of Supplement A to 2.2 lb. However, the level of salt necessary to control the intake of protein supplement appears to be governed by several factors and thus must be adjusted in accordance with the conditions of any particular feeding situation. Riggs *et al.* (1953) reported a level of 35% added salt as necessary to control the daily intake of free choice cottonseed meal to 2.06 lb. for pregnant beef cows having access to dry winter forage consisting principally of Bluestem and Bermuda grasses. A level of 25% salt in the cottonseed meal limited the consumption of cottonseed meal to 4.41 lb. per head daily. Archer *et al.* (1952) reported a level of 30% salt limited the consumption of cottonseed cake to 2.6 lb. per day for brood cows on dry native Oklahoma grass. In later Oklahoma research (Nelson *et al.*, 1953) an average of limited cottonseed meal consumption to 2.6 lb. per day for brood cows allowed to graze dry cured grass during the winter season.

Apparently, on a more palatable ration, such as a full feed of corn, less salt is required to control the intake of free choice supplement than is required on a less palatable ration as weathered range grasses.

The use of salt to control feed intake exerts no deleterious effects on cattle, apparently. No scouring was observed in such cattle under the conditions of this experiment. In metabolism studies, Archer *et al.* (1952) and Cardon (1953) reported that levels as high as 2 lb. daily salt intake had no effect on digestibility of protein, cellulose or crude energy. Riggs *et al.* (1953) observed beneficial effects upon cellulose digestion from higher levels of salt.

Under the conditions of these no advantage from offering hay to self-fed cattle was observed. In three of the four trials, hay was offered throughout the fattening period. In one of the four trials (Trial III) mixed hay was offered only for the first 28 days of the trial, and then no additional hay was offered. Apparently the cob portion of ground ear corn provides sufficient roughage for the physiological well-being of cattle fattened on ground ear corn and protein supplement, as previously shown by Geurin *et al.* (1955).

Summary

Feeder cattle that had not received corn previously were turned into feeding lots (either drylot or pasture) in which feed bunks, filled with concentrates, were accessible.

Cattle were successfully fattened on a self-fed free choice ration of ground ear corn, Supplement A (32% protein supplement), minerals and

hay. On this type of program, the cattle ate excessive amounts of Supplement A—as much as 7.6 lb. per day in one experiment. However, no ill effects were observable from eating excessive amounts of Supplement A. In fact, these cattle gained significantly more rapidly and produced carcasses which graded higher than cattle fed less protein supplement.

Cattle may be fattened successfully on a self-fed ration consisting of a combination of ground ear corn and Supplement A. It appeared that the optimum ratio is 8 parts ground ear corn to 1 part Supplement A.

Cattle may be self fed a fattening ration consisting of ground ear corn, free choice, Supplement A to which an additional salt has been added, free choice, and hay, free choice. Under the conditions of this trial, 5% of added salt controlled the Supplement A intake of 2.2 lb. per day.

At no time did cattle fattened on any of the above three recommended methods show signs of scouring or of going off feed from the first day they were turned into the feedlots to eat according to appetite.

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RUMINANT UTILIZATION OF INORGANIC PHOSPHATES

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IN view of the widespread use and multiplicity of choice of phosphate supplements for animal rations, the availability of phosphate in its varied forms is a practical problem. This subject has been investigated recently for poultry (Miller and Joukovsky, 1953; Grau and Zweigart, 1953; Gillis *et al.*, 1954; and Wilcox *et al.*, 1954, 1955) and swine (Gobble *et al.*, 1954; Chapman *et al.*, 1955, and Plumlee *et al.*, 1955) but few critical studies with ruminants have been reported.

These studies were undertaken to evaluate several commonly used phosphate supplements, as well as pure calcium ortho-, meta-, and pyrophosphates, incorporated in rations for steers and lambs.

The chemical composition of the supplements used in this study is shown in table 1. Two feeding-grade dicalcium phosphates "A" and "D", produced by similar electrothermal processes, and two defluorinated rock phosphates were included in the test. Both defluorinated products were calcined calcium phosphates, sample "C" having been acidulated with sulfuric acid and sample "G" with phosphoric acid. The bone meal sample had been prepared from fresh wet-processed bones, dried at a low temperature and then ground. Curacao Island phosphate is a raw rock phosphate, naturally low in fluorine, which is mined and ground without further processing. Soft phosphate with colloidal clay contains finely divided phosphate particles together with large amounts of clay and other impurities which have been washed from the matrix during the process of mining rock phosphate in North Central Florida. These phosphate supplements were obtained on the open market and were not composited.

Steers—Experiments 1 and 2

Procedure. Six yearling beef steers purchased from a phosphorus-deficient soil area were used in Experiment 1. They received a low-phosphorus ration of long prairie hay plus a pound of corn gluten meal per steer daily for 126 days prior to the beginning of the experiment. The steers had an average weight of 487 lb. when purchased and 545 lb. at the start of the experiment.

[1] This paper is part of a thesis submitted by the senior author to the Graduate College, University of Illinois, in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Animal Science. Present address: U. S. Army Medical Nutrition Laboratory, Fitzsimons Army Hospital, Denver, Colorado.

[2] The authors are indebted to Monsanto Chemical Company, Dayton, Ohio, for supplying the calcium ortho-, meta- and pyrophosphates, for chemical analysis, and for providing funds with which this investigation was initiated; and to Mallinckrodt Chemical Works, St. Louis, Missouri, for providing some analytical data on the products tested.

TABLE 1. CHEMICAL COMPOSITION OF PHOSPHATIC SUPPLEMENTS

Source of Phosphorus	Code letter	Chemical constituents					Interpretation of X-ray patterns [a]
		P	Ca	Fe	Al	F	
		%	%	%	%	%	
Dicalcium	A	17.46	29.31	0.049	0.13	0.01	80/20, Anhyd. DCP/$CaCO_3$
Bone meal	B	12.64	28.45	0.007	0.08	0.07	Apatite-TCP
Defluorinated	C	12.50	35.10	0.650	0.65	0.10	60/10/30, Beta TCP/$CaCO_3$/?
Dicalcium	D	19.23	31.39	0.280	0.08	0.003	90/10, Anhyd. DCP/$CaCO_3$
Curacao Island	E	14.53	35.46	1.007	1.36	0.54	50/30/20 Apatite-TCP/ $CaCO_3$/Beta TCP
Soft	F	8.78	20.23	2.189	6.62	1.44	50% Apatite-TCP, Some Anhyd. DCP
Defluorinated	G	17.62	30.00	.....	....	0.16	Mostly Beta TCP, Some Anhyd. DCP

[a] DCP=dicalcium phosphate; TCP=tricalcium phosphate.

The first six phosphatic supplements (A-F) shown in table 1 were used in this experiment. The statistical design was a 6×6 Latin square, each treatment preceding each other treatment but once. Steers were assigned to columns and letters to supplements at random. Each of the six seven-day collection periods was preceded by a preliminary feeding period of at least 21 days. Urine and feces were collected separately in metabolism stalls described by Horn *et al.* (1954). Heparinized venous blood samples and individual weights were obtained at the beginning of the experiment and following each collection period. Blood calcium and phosphorus determinations, and phosphorus determinations on the rations, feces and urine, were made according to A.O.A.C. methods (1950).

TABLE 2. COMPOSITION OF BASAL CONCENTRATES [a]

Ingredients	Experiment	
	1	2
	Pounds	
Cerelose	70.8	67.5
Corn starch (granulated)	....	25.0
Corn gluten meal	22.3	....
Urea (cryst.)	4.4	4.8
Corn oil	2.0	1.0
Trace mineralized salt (0.004% P)	0.5	0.7
Vitamin A & D oil (3000A-600D)	....	1.0
	100.0	100.0

[a] The concentrate used in Experiment 2 did not prove to be as satisfactory as that used in Experiment 1. The oils, perhaps mainly the vitamin A and D oil, in the second concentrate became rancid within a few days after mixing. Most of the steers ate the rank-smelling concentrate fairly well but did so with some hesitation. The addition of granulated starch seemed satisfactory except for one steer which was inclined to separate the starch grains and leave them in the feed bunk. The concentrate used in Experiment 1 worked well with all phosphatic supplements except soft phosphate. The soft phosphate supplemented rations developed a slightly rancid odor and were not eaten well by some steers. The addition of corn syrup or anise oil in ethyl alcohol to the concentrate at feeding time and mixing it with the chopped hay resulted in improved feed intake.

The basal concentrate used is shown in table 2. The phosphorus supplements and calcium carbonate were added at the expense of cerelose to give the desired level of phosphorus and a Ca:P ratio of 1.5:1. The concentrate (.104% P) was fed at 4.5 lb. per steer daily in all periods. Chopped prairie hay (.07% P) fed at 6.5 to 7.5 lb. per steer daily, made up the roughage part of the ration.

On the basis of investigations by Archibald and Bennett (1935) and Beeson *et al.* (1941), a level of 1.70 gm. of phosphorus per hundred lb. of body weight was considered suboptimal for good gains. Thus on the basis of initial weight, the ration was formulated to provide a total intake of approximately 9 gm. phosphorus per steer daily, approximately 4.7 gm. being supplied by the phosphate supplement.

In Experiment 2, the availability of the phosphorus in dicalcium phosphate "A" and defluorinated phosphate "G" was compared. The two treatments were each assigned at random to three of the six steers used in Experiment 1. One steer receiving product "G" went off feed just as the collection period began and thus failed to complete the trial.

The ration used in the first experiment was modified for use in this trial (table 2). To further reduce the phosphorus content, urea replaced corn gluten meal to maintain the desired nitrogen level. Urea made up 2.1% of the total dry matter (concentrate plus roughage) and provided about 90% of the calculated digestible nitrogen. The total phosphorus intake was approximately 8 gm. per steer daily. As the steers now averaged about 740 lb., they received slightly more than 1 gm. of phosphorus per 100 lb. of body weight, of which approximately 66% was supplied by the mineral supplement.

Results. During the depletion period the steers made an average daily gain of 0.46 lb. During the supplemental period (218 days) of Experiment 1 the steers gained an average of 0.85 lb. daily. Individual values were plotted in figure 1.

Urine collections were not continued after it was found that only 1% of phosphorus excreted was by this pathway. Thus the balance data reported are based on total phosphorus intake less fecal phosphorus.

Average values for percentage phosphorus retention in Experiment 1 are shown in table 3 and figure 1. Average values ranged from 28% for soft phosphate to 33% for one of the dicalcium phosphates. Statistical analysis revealed no substantial indication that the treatment differences were real. Differences between steers were found to be significant at the 5% point. Analysis of the data revealed a correlation of 0.83 (significant at the 5% level) between mean phosphorus retention and mean average daily gain, suggesting that the good gainers were also good retainers of phosphorus. However, when the response between periods or treatments was considered, the correlation of percent phosphorus retention with average daily gain was practically zero. This low correlation probably reflects the large observational error in average daily gains of steers over short intervals

of time. When considering the entire experiment, the coefficient of variation for the measurement of retention was 20% while that for the measurement of average daily gain was 140%.

A significant improvement in the utilization of phosphorus was noted as the experiment progressed. This improvement was confounded with various factors, among them the decreasing level of phosphorus and an increasing

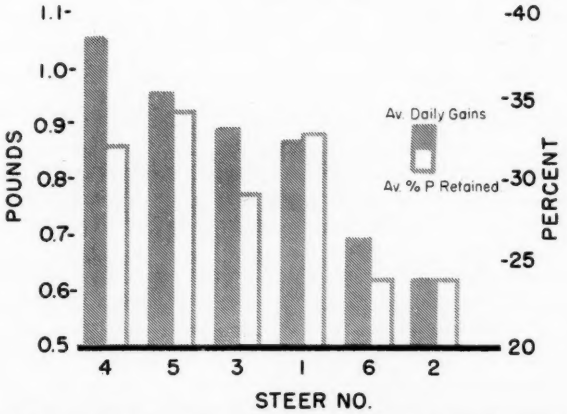

Figure. 1. Comparison of average daily gains during the supplemental period with average percent total phosphorus retained, Experiment 1.

body weight as the test progressed. Statistical analysis did not reveal a correlation between per cent phosphorus retained and phosphorus intake per 100 lb. body weight.

Experiment 1 was designed so that effects of previous treatment could be determined by statistical analysis. The data showed no appreciable carry-over effect from one treatment to the next.

Following the depletion period, the average blood plasma calcium and inorganic phosphate levels, expressed in milligrams per 100 ml., were 11.2 ± 0.8 (standard deviation) and 6.8 ± 0.9, respectively. The blood calcium and phosphorus levels did not appear to be affected by treatment and averaged 12.1 ± 0.3 and 7.5 ± 0.9, respectively, at the conclusion of the test.

In Experiment 2, dicalcium phosphate "A" and defluorinated phosphate "G" appeared to be equally effective as phosphorus sources. The two-year-old steers received 8.64 or 8.37 gm. of phosphorus daily from the two rations, respectively, and were essentially in phosphorus equilibrium.

Lambs—Experiment 3

Procedure. Defluorinated phosphate "G", soft phosphate, Curacao Island phosphate and commercial dicalcium phosphate "A" (selected at random

TABLE 3. AVERAGE PERCENTAGE OF TOTAL PHOSPHORUS INTAKE RETAINED FOR STEERS, PERIODS AND TREATMENTS, EXPERIMENT [a]

Steer or period no.	Steers	Periods	Treatments	Code letter
1	33	25	33	A
2	24	22	30	B
3	29	34	29	C
4	32	34	31	D
5	34	29	25	E
6	24	32	28	F

[a] Each retention value represents the average of six figures for one particular steer, collection period, or treatment.

from the two dicalcium phosphate samples) were chosen to be tested with lambs. These materials were taken from the same samples as those used for the steer work. Phosphorus balance and blood phosphorus levels were used as criteria.

Sixteen weanling, wether, crossbred Suffolk lambs were used in Experiment 3. They were handled in two staggered groups of 8 lambs each because of space limitations. Initially, the lambs ranged in weight from 52 to 78 lb. with an average of 62 lb. for both groups and were probably not over 3 months of age.

The basal ration (table 4) was a semi-purified mixture modified from

TABLE 4. COMPOSITION OF BASAL RATION, EXPERIMENTS 3 AND 4

Ingredient	Pounds
Starch (granulated)	25.0
Cerelose	24.5
Woodflock	15.0
Prairie hay (ground)	15.0
Alfalfa hay (ground)	5.0
Mineral mixture [a]	4.4
Urea (cryst.)	4.0
Gelatin	4.0
Corn oil	3.0
Choline	0.1
Vitamin A & D [b]	+
Vitamin mixture [c]	+
	100.0

[a] The percentage composition was as follows: 34.9 Na_2SO_4, 33.8 $K_3C_6H_5O_7 \cdot H_2O$, 15.4 iodized NaCl, 7.50 $CaSO_4 \cdot 2H_2O$, 5.83 $MgCO_3$, 2.36 $(C_6H_5O_7) \cdot 6H_2O$, 0.122 tech. grade $MnSO_4 \cdot 4H_2O$, 0.028 $CuSO_4 \cdot 5H_2O$, 0.024 $CoCl_2 \cdot 6H_2O$, 0.020 $ZnCl_2$, 0.020 CaF_2, and 0.003 MoO_3. Modification of mineral mixture of Thomas *et al.* (1951).

[b] Quadrex, product of Nopco Chemical Co., Harrison, N. J. Contained 4,000 units A and 500 units D per gm. Added at level of 1 gm. per lb. of ration.

[c] Vitamins added in mg. per lb. of ration: 0.9 2-methyl-1, 4- naphthoquinone, 14.0 ascorbic acid, 2.25 thiamine HCl, 4.5 riboflavin, 2.25 pyridoxine HCl, 27.0 calcium pantothenate, 90.0 inositol, 10.0 p-aminobenzoic acid, 0.03 biotin, 18.0 niacin, 0.2 folic acid, 5.0 alpha tocopherol acetate, and 0.015 vitamin B_{12}.

one employed by Starks *et al.* (1953). Ground prairie and alfalfa hays were added as palatable sources of fiber. Gelatin was used as a source of preformed protein extremely low in phosphorus. A complete water-soluble vitamin mixture was added as a precautionary measure. This ration contained 0.032% phosphorus by analysis, and was calculated to contain 0.22% calcium and 17% conventional protein equivalent. All lambs received the basal ration for 4 weeks, during which feed intakes of 600 to 700 gm. per lamb daily were established. The ration was fed twice daily and water was provided *ad libitum*. Fecal and urine collections of 5 to 7 days' duration were made during the latter part of the 4-week depletion period.

One to two days following completion of collections during the basal period, supplementary feeding of phosphorus, and fecal and urine collections, were begun simultaneously. This supplemental feeding lasted for 12 days during which four 3-day collections were made. Lambs were assigned to treatment and to metabolism crates at random.

Venous blood samples were drawn at the beginning of the test, and also just before and following the supplemental feeding period. Phosphorus determinations were made on the serum. Based on the work of Beeson *et al.* (1944), it was felt that a phosphorus level of 0.14 to 0.16% in the supplemented rations would be well below the requirement for these lambs. The actual phosphorus levels in the supplemented rations ranged from 0.154 to 0.158%. Thus, since the basal ration contained 0.032%, almost 80% of the total phosphorus fed was supplied by the mineral source. The phosphorus supplements and calcium carbonate were added at the expense of cerelose to give the desired phosphorus level and a Ca:P ratio of 3.5:1.

Results. No gain in weight was made during the test. The lambs averaged 62 lb. initially, 61 lb. following depletion and 62 lb. following the 12 days of supplemental phosphorus feeding with no great fluctuation in the weight of any single lamb.

Phosphorus excreted by way of the urine was not considered in calculating phosphorus retention values since, for the basal and fourth supplementary collection, an average of only 11 and 14 mg. of phosphorus, respectively, was excreted daily in the urine.

Fecal phosphorus excretion data for the basal period were available for only 12 of the 16 lambs which completed the supplemental phosphorus feeding period. All 12 lambs which completed both the basal and supplemental periods were in negative phosphorus balance during the basal collection. They received 0.22 gm. of phosphorus per lamb daily and excreted an average of 0.56 gm. of phosphorus daily. The fecal phosphorus excretion for these 12 lambs while consuming the basal ration can be regarded as approximating metabolic fecal phosphorus. It was found to have a correlation of 0.59 with body weight, significant at the 5% level.

Figure 2 shows the average total fecal phosphorus excreted daily by the lambs during the collection periods. All lambs excreted about the same

amount of phosphorus during the basal period, but, as time passed, the lambs receiving either soft phosphate or defluorinated phosphate "G" began to excrete greater quantities of phosphorus than those lambs consuming either dicalcium phosphate "A" or Curacao Island phosphate. As evidenced by the poor phosphorus retention during period two, it appeared that soft phosphate had an early adverse effect which was gradually alleviated to some degree.

The percent phosphorus retention values for the series of four 3-day collection periods were tested by multivariate analysis. The analysis indicated that the response obtained during each of periods one and two dif-

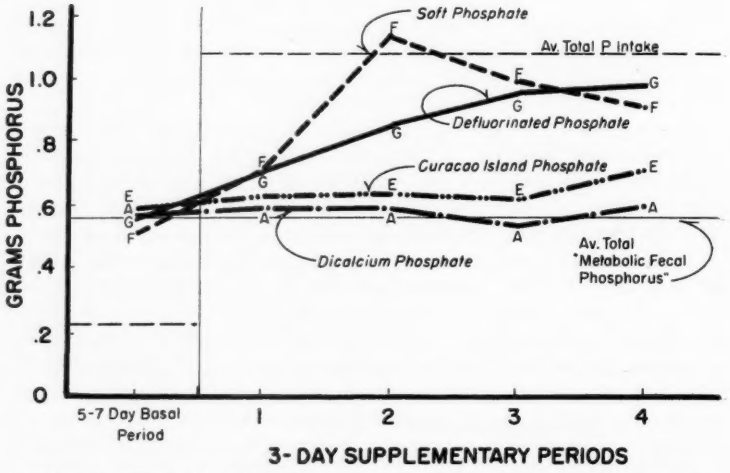

Figure 2. Effects of phosphate source on average total fecal phosphorus excreted daily, Experiment 3.

fered from all following periods and the response in periods three and four was similar. From this it appears that approximately six days of supplemental phosphorus feeding are required as an adjustment period before satisfactory results can be obtained.

No significant difference in response of animals fed different phosphate supplements could be detected during the first 3-day period. In the second 3 days, differences in retention between sources had reached the 5% level of significance while in the third and fourth 3-day periods, the retention values differed significantly beyond the 1% level. The results obtained from the third and fourth periods proved to be a slightly more precise measure of phosphorus availability when combined than when considered as individual 3-day collections. For the supplemental rations containing

dicalcium phosphate "A", Curacao Island phosphate, soft phosphate and defluorinated phosphate "G" the average retention values for the combined third and fourth periods with 4 lambs per treatment were 46, 38, 13 and 11%, respectively. These average retention values, in addition to individual values for lambs, are shown in table 5. It is of interest that more uniform

TABLE 5. PER CENT OF TOTAL PHOSPHORUS INTAKE RETAINED, EXPERIMENT 3 [a]

	Treatment			
	Dicalcium phosphate "A"	Curacao phosphate "E"	Soft phosphate "F"	Defluorinated phosphate "G"
	53	46	12	11
	41	41	23	—10
	44	33	7	8
	45	30	12	34
Av.	46	38	13	11

[a] Values based on the combined third and fourth collection periods.

retention values were obtained with the better utilized phosphatic sources.

As a means of securing a truer evaluation of the various materials as phosphate carriers, a method of calculating phosphorus absorption was used which took into consideration the fecal phosphorus excreted during the basal period. A somewhat similar technique was employed by Godden and Ray (1938) and Otto (1938).

A "true" absorption percentage was obtained as follows:

$$\frac{\text{(Total P int.—P in basal ration)—(Total P exc.—basal P exc.)}}{\text{Total P intake— P in basal ration}} \times 100$$

When this calculation was made, average "true" absorption percentages for the combined third and fourth collection periods were 100 ± 6 (standard deviation), 90 ± 18, 50 ± 10, and 54 ± 12, respectively for the dicalcium phosphate "A", Curacao Island phosphate, soft phosphate, and defluorinated phosphate "G".

Blood serum inorganic phosphate levels, expressed in mg. per 100 ml., averaged 10.3 ± 2.3 (standard deviation) initially and 6.1 ± 1.1 following the depletion period. The average increase in serum phosphorus during the 12-day repletion with dicalcium phosphate "A", Curacao Island phosphate, soft phosphate and defluorinated phosphate "G" was 2.4, 2.6, 1.3 and 1.3, respectively. These values do not differ significantly.

Lambs—Experiment 4

Calcium meta- and pyrophosphates may be formed during the process of thermal defluorination and thus may be present in the end product. The objective of Experiment 4 was to compare the utilization by lambs of these two phosphates with an orthophosphate since no literature reference

to this was found. Monocalcium phosphate monohydrate [Ca $(H_2PO_4)_2 \cdot H_2O$], vitreous calcium metaphosphate [$Ca(PO_3)_2$] and gamma calcium pyrophosphate [$Ca_2P_2O_7$] were used in this test. The calcium meta- and pyrophosphates were obtained by ignition of mono- and dicalcium phosphates, respectively. The crystalline structure of the resulting materials was verified by X-ray diffraction patterns.

Procedure. Six ewe and six wether weanling lambs were selected from the same lamb crop as those used in the previous experiment. Initially the lambs ranged in weight from 52 to 66 lb., with an average of 59 lb. The basal ration (table 4) was fed for 30 days during which equalized feed intakes of 650 gm. per lamb daily were established. No collection was made while the lambs received the basal ration.

Six days prior to the supplemental feeding of phosphorus, the lambs were put in metabolism crates. The supplemental feeding period consisted of four 3-day collection periods. Urine and feces were collected and three sets of venous blood samples were drawn as previously described.

Phosphorus levels in the supplemented rations ranged from 0.136 to 0.139% while the basal mixture for this test contained 0.034% phosphorus. The Ca:P ratio was maintained at 3.5:1. Two female and two wether lambs were assigned at random to each of the three treatments.

Results. The lambs weighed an average of 56 lb. following the 30-day depletion period (an average loss of 3 lb. per lamb) and 57 lb. after the 12-day supplemental period. Weight fluctuations were about the same for all lambs.

As in the previous work, the urine did not contain appreciable quantities of phosphorus and thus was not included in calculating phosphorus balance. Statistical analysis of the balance data showed a linear decrease in percentage of phosphorus retained for all treatments as the supplementary feeding period progressed. The response curves sloped at the rate of —11.9% per 3-day period with only a slight indication that the 3 response curves were not of equal slope. Each response curve was significantly different ($P=0.02$) from the other 2. For the entire 12-day collection, average total phosphorus retention values of 26, 0, and —21% were obtained for the ortho-, meta- and pyrophosphates, respectively.

Figure 3 shows the average amount of phosphorus excreted daily during the four 3-day periods. The amount of phosphorus excreted daily continued to increase for all compounds throughout the repletion period, thus differing from results obtained in the first lamb experiment.

When an average metabolic fecal phosphorus level, based on results from the previous lamb experiment, was estimated for this group of lambs, average "true" absorption values for the last 3-day collection period of 40, 10 and —22% were calculated for the ortho-, meta- and pyrophosphates, respectively. These values indicate an increased metabolic fecal phosphorus excretion due to the ingestion of calcium pyrophosphate. If the pyrophosphate was essentially unavailable but was not stimulating

excessive excretion of phosphorus by the lamb, the average "true" absorption should have come to zero, instead of to —22%. Assuming the necessary higher level of average metabolic fecal phosphorus the respective average "true" absorption values become 63, 34 and 0%.

Blood serum inorganic phosphate levels, expressed in mg. per 100 ml., averaged 10.0±1.8 (standard deviation) initially and 5.9±0.9 following the depletion period. The average increase during the 12-day repletion period was 2.5, 1.2, and 0.7 for monocalcium phosphate, calcium metaphosphate and calcium pyrophosphate, respectively. These values were significantly different at the 2% level.

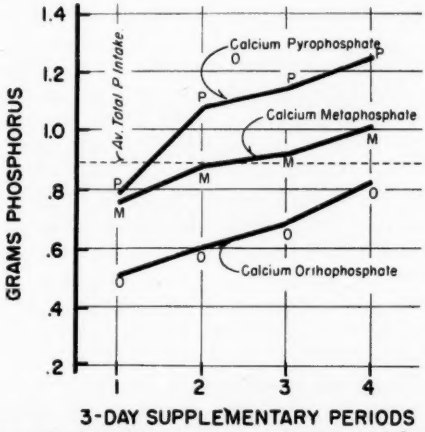

Figure 3. Effects of phosphate source on average total fecal phosphorus excreted daily, Experiment 4.

Discussion

Commercial phosphates. Seven commercial phosphates tested with yearling steers appeared to be equally effective as a source of phosphorus. However, soft phosphate and defluorinated phosphate "G" proved to be only about 50% as effective as Curacao Island phosphate or dicalcium phosphate "A" as phosphatic sources for lambs. Thus, young rapidly growing lambs apparently provided a more critical test of the availability of the inorganic phosphates than did the steers. Several factors may have contributed to this finding: (1) A basal ration lower in phosphorus was formulated for the lamb work which permitted almost 80% of the total phosphorus in the ration to be supplied by the inorganic source, while only about 50 or 66% came from the inorganic phosphate in steer Experiments 1 and 2, respectively. (2) The lambs probably had a relatively higher phosphorus requirement, because they were less mature than the steers. (3) The low-phosphorus basal ration plus the higher phosphorus require-

ment permitted a more thorough depletion of phosphorus stores in the lambs than with steers.

Based primarily on feedlot or range studies, investigators in general have reported bone meals, commercial dicalcium phosphates and defluorinated phosphates to be satisfactory sources of phosphorus for cattle (Knox *et al.*, 1941; Black *et al.*, 1943; Becker *et al.*, 1944; Gullickson and Olson, 1946; and Hodgson *et al.*, 1948). However, Beeson *et al.* (1945) reported that, in a 140-day feeding trial, yearling steers made unsatisfactory daily gains when supplemental phosphorus was provided as defluorinated phosphate. The apparent low availability of the phosphorus in the defluorinated material was explained on the basis of a chemical analysis which indicated that only one-half of the phosphorus present was in the more soluble ortho form.

Results of feeding trials with cattle reported by Long *et al.* (1956), with dicalcium phosphate and soft phosphate are in general agreement with the findings reported here for lambs. These workers suggested that the unsatisfactory response to the soft phosphate may have been due to a combination of phosphorus deficiency and fluorine toxicity. It is doubted that fluorine, at least as a toxic agent, influenced the results of the present short term experiments with lambs which showed the phosphorus in soft phosphate to be approximately 50% as available as that in dicalcium phosphate.

It is of interest that results with soft phosphate obtained using an artificial rumen technique (Anderson *et al.*, 1956) are also in general agreement with the results obtained with lambs. However, a sample of Curacao phosphate tested by these workers appeared to be much less available than dicalcium phosphate, while in the present studies the Curacao phosphate sample employed was equal to dicalcium phosphate as a source of phosphorus.

The low availability of the phosphorus in soft phosphate cannot be fully explained at present. However, the iron and aluminum compounds in the soft phosphate are present in amounts sufficient to combine with all of the phosphorus to form the rather insoluble iron and aluminum phosphates. The iron and aluminum probably occur predominantly as oxides, which are relatively insoluble, but this does suggest one way in which the phosphorus in soft phosphate may become biologically unavailable. X-ray analysis of the soft phosphate indicated that most of the phosphorus was present as an apatite.

The unsatisfactory response obtained with the "G" sample of defluorinated phosphate suggested the presence of either meta- or pyrophosphates or both, but X-ray diffraction patterns indicated that most of the phosphorus was present at beta tricalcium phosphate, with no evidence of the occurrence of either meta- or pyrophosphates.

The relative availability of all commercial phosphates used in this work was tested using the chick as the assay animal (Ammerman, 1956).

Dicalcium phosphate "A", Curacao Island phosphate, soft phosphate and defluorinated phosphate "G" gave values of 74, 54, 49 and 32%, respectively, when compared to the bone-ash response produced by sodium acid phosphate, while the "true" absorption values for lambs for these materials were 100, 90, 50, and 54%, respectively. Although not in close agreement, the differences are similar for the two species. Dicalcium phosphate "D", bone meal and defluorinated phosphate "C" gave values of 82, 74, and 62% when compared with sodium acid phosphate as a source of phosphorus for the chick.

Ortho-, meta- and pyrophosphates. Finding that the vitreous calcium metaphosphate and gamma calcium pyrophosphate were relatively unavailable to lambs is in agreement with earlier work conducted with other species of animals. Fraser *et al.* (1943) and Ellis *et al.* (1954) working with rats, and Matterson *et al.* (1945), Bird *et al.* (1945), and Gillis *et al.* (1948, 1954), working with chicks, found that calcium meta- and pyrophosphates were less available than orthophosphate. There is also evidence in the literature that the degree of availability of the calcium meta- and pyrophosphates may depend upon the form or the enantiotropic crystalline modification in which they exist. In recent work with highly purified diets, Gillis *et al.* (1948, 1954) found the *alpha, beta* and *gamma* calcium pyrophosphates almost completely unavailable as a source of phosphorus for the chick. Vitreous calcium metaphosphate was found to be 45% as available as *beta* tricalcium phosphate while both *beta* and *gamma* calcium metaphosphate were found to be almost totally unavailable as sources of phosphorus. On the basis of "true" absorption values the vitreous calcium metaphosphate used in this work appeared to be approximately 50% as effective as monocalcium phosphate as a source of phosphorus for lambs.

The reason for the relative unavailability of the meta- and pyrophosphates in general has not been revealed. Whether the difficulty lies in the problem of solubility and absorption or in the ability of the animal body to utilize what is absorbed is not known. However, crystalline phosphates are capable of forming polymers of varying lengths (Hendricks, 1944) and if this occurred in the intestine absorption might be impeded.

With the problem of absorption in mind, it is interesting to consider the blood phosphorus data. When the blood phosphorus levels at the end of depletion and following supplemental feeding of *gamma* calcium pyrophosphate were analyzed as paired data, the average improvement of 0.7 mg. per 100 ml. in blood phosphorus approached the 5% level of significance ($P=0.053$). It appears that there may have been a real increase in blood phosphorus levels for this treatment. This may indicate that some absorption and ultimate excretion of the pyrophosphate was taking place, as the balance studies indicated that the calcium pyrophosphate was almost totally unavailable to the lambs.

The values obtained for both meta- and orthophosphate represented real increases in blood phosphorus, although the metaphosphate had not

produced a positive phosphorus balance. However, the metaphosphate did appear to be utilized to some extent by the lambs when a value for metabolic fecal phosphorus was considered. It is suggested that some calcium metaphosphate may have been hydrolyzed to calcium monophosphate in the intestinal fluids and thus became available. Further work indicated that no substantial amounts of phosphorus were absorbed from either vitreous calcium metaphosphate or *gamma* calcium pyrophosphate within 7 hours after oral dosing in lambs, while a significant amount ($P=.03$) of phosphorus was absorbed from monocalcium phosphate in the same period, as measured by blood phosphorus levels.

Summary

Steers and lambs were used to ascertain the relative availability of various inorganic phosphatic materials for ruminants, using phosphorus balance and inorganic blood phosphorus levels as criteria. Yearling steers, which had received rations low in phosphorus for 4 months, were fed approximately 1.70 or 1.00 gm. of phosphorus per 100 weight daily in successive experiments, of which 50% in the first experiment and 66% in the second experiment was supplied by inorganic phosphatic material. Weanling lambs were depleted of phosphorus stores by feeding a semi-purified ration containing about 0.03% organic phosphate. Following depletion, the lambs were fed experimental rations containing 0.13 to 0.16% phosphorus of which almost 80% came from the inorganic sources.

Two commercial, electrothermally produced, dicalcium phosphates, two calcined defluorinated phosphates, and one sample each of bone meal, soft phosphate with colloidal clay, and Curacao Island phosphate were of equal value in promoting phosphorus retention and maintaining blood phosphorus levels in yearling steers.

Of the 4 commercial phosphate samples tested with lambs, dicalcium phosphate and Curacao Island phosphate were well utilized but soft phosphate and a calcined defluorinated phosphate were poorly utilized. *Gamma* calcium pyrophosphate was essentially unavailable to lambs. Vitreous calcium metaphosphate was utilized to some extent but significantly less so than was the orthophosphate (monocalcium phosphate).

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THE EFFECTS OF ADEQUATE AND EXCESSIVE CALCIUM WHEN FED WITH ADEQUATE PHOSPHORUS IN GROWING RATIONS FOR BEEF CALVES[1]

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GROWING beef calves are generally fed high roughage—low concentrate rations. Rations which are composed chiefly of roughages frequently contain wide ratios of calcium to phosphorus. Further, mineral supplements added to growing rations often have wide ratios of calcium to phosphorus. Therefore, it occasionally happens that beef calves are fed rations with 6 or 8 times as much calcium as phosphorus.

A calcium phosphorus ratio between 2 to 1 and 1 to 2 is generally considered desirable for optimum nutrition (Maynard and Loosli, 1956). Evidence indicates that adequate nutrition can occur outside of these ratios provided that each element is present in adequate amounts, and that ample vitamin D is present.

Ruminants apparently are not as sensitive to wide calcium-phosphorus ratios as are monogastric animals like pigs. Bohstedt (1955) summarized the results obtained with swine fed different ratios of calcium to phosphorus. He stated, "The results indicate that ratios ranging from 1.1 to 1.5 parts of calcium to 1 part of phosphorus have been observed as favorable." Lactating dairy cows have been fed rations with calcium-phosphorus ratios varying from 0.6–1.0 to 10.5–1.0 (Kuhlman *et al.*, 1936; Haag *et al.*, 1932) without apparent ill effect. Colovos *et al.* (1952, '53, '54 and '55) reported that excess calcium does depress the digestibility of protein and energy in rations fed to dairy heifers. However, few data are available showing the effects of excessive levels of calcium on the performance of growing beef calves.

The objective of this experiment was to compare the effects of feeding adequate and excessive calcium on the performance of growing calves fed adequate phosphorus.

Experimental Procedure

Two 140-day feeding trials were conducted with Hereford steer calves of an approximate initial age and weight of 8 months and 475 lb., respectively. In both years the calves were purchased from the same herd, insuring similar background and treatment immediately prior to each trial.

All calves were given free access to prairie hay and were also fed 4 lb. of ground shelled corn and 1 lb. of soybean oil meal per head daily. The

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ground limestone fed to the steers in lots 2, 3 and 4 was mixed with the ground shelled corn and soybean oil meal and fed in open bunks once daily in the morning. The calves had free access to an ample supply of water. No supplemental vitamin D was fed in this experiment, but they were exposed to usual sunshine.

The rations, shown in table 2, furnished 4 different calcium-phosphorus ratios, but approximately equal levels of other nutrients. The average level of phosphorus fed daily per calf in all lots was approximately 12 gm., the amount suggested by the National Research Council Subcommittee on Beef Cattle (1950). Thus, all calves received an adequate amount of

TABLE 1. PROXIMATE COMPOSITION OF FEEDS

	Dry matter	Crude protein	Fat	Fiber	Ash	NFE	Ca	P	Ca Gm.	P Gm.
		%	%	%	%	%	%	%	lb.	lb.
Prairie hay										
Trial I	89.0	6.4	1.4	32.4	6.5	42.7	0.31	0.10	1.41	0.45
Trial II	89.5	6.5	1.7	30.4	6.6	44.3	0.32	0.08	1.45	0.36
Average	89.2	6.45	1.55	31.4	6.5	43.5	0.315	0.09	1.43	0.40
Corn										
Trial I	87.0	9.3	3.2	2.0	2.0	70.5	0.03	0.28	0.14	1.27
Trial II	86.1	9.0	3.0	1.9	2.0	70.2	0.03	0.30	0.14	1.36
Average	86.6	9.2	3.1	2.0	2.0	70.4	0.03	0.29	0.14	1.32
Soybean oil meal										
Trial I	91.0	42.2	5.3	5.6	6.0	31.9	0.29	0.52	1.32	2.36
Trial II	89.6	40.9	4.9	5.0	5.8	35.0	0.28	0.54	1.27	2.45
Average	90.3	41.6	5.1	5.3	5.9	33.4	0.29	0.53	1.30	2.40
Limestone										
Trial I	....	....	....	....	....	....	38.0	....	172.52	....
Trial II	....	....	....	....	....	....	37.0	....	167.98	....
Average	....	....	....	....	....	....	37.5	....	170.25	....

phosphorus and either an adequate or an excessive amount of calcium. The calcium was varied by adding ground limestone to the rations fed in lots 2, 3 and 4.

The composition of the feeds used as determined by conventional feed analysis is presented in table 1.

In each trial the steer calves were randomly assigned to the treatments on the basis of weight. In trial I, 10 calves were used on each of the 4 treatments. In trial II, 9 calves were used on each of the 4 treatments. Otherwise trial II was a replication of trial I. The initial and final weights, shown in table 2, are the averages of 3 weights taken on consecutive days at the beginning and end of each trial.

Blood samples of about 50 ml. were taken from the jugular veins of all calves at the beginning and end of trial I. During trial II blood samples were taken from the calves only in lots 1 and 4. The plasma calcium was

TABLE 2. SUMMARY OF TRIALS I AND II (140 DAYS)

	1949–1950				1950–1951			
Lot number	1	2	3	4	1	2	3	4
No. steers/lot	10	10	10	10	9	9	9	9
Av. initial wt., lb.	483.7	482.9	483.5	482.5	464.4	464.4	466.1	464.4
Av. final wt., lb.	666.5	654.0	640.0	633.5	653.3	657.8	627.2	622.8
Av. gain/head, lb.	182.8	171.1	156.5	151.0	188.9	193.4	161.1	158.4
Av. daily gain/head, lb.	1.31	1.22	1.11	1.08	1.35	1.38	1.15	1.13
Average daily ration per head, lb.:								
Prairie hay	9.76	9.51	9.75	9.64	9.56	9.93	9.86	9.69
Corn	4.00	4.00	4.00	4.00	4.06	4.06	4.06	4.06
Soybean oil meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	none	0.19	0.53	0.86	none	0.22	0.53	0.83
Feed consumed per 100 lb. live weight gain, lb.:								
Prairie hay	748	778	872	894	708	716	858	853
Corn	306	327	358	371	301	293	353	357
Soybean oil meal	77	82	89	93	74	72	87	87
Limestone	none	16	47	80	none	16	46	73

determined by the method of Clark and Collip (1925) and the plasma inorganic phosphorus was determined by the method of Fiske and Subbarow (1925) as outlined by Hawk *et al.* (1947).

Results and Discussion

The results of the two trials are summarized in table 2. In table 3 the average amounts of calcium and phosphorus consumed per calf daily are presented. The average daily gains per head for the two trials are presented in table 4.

These data (table 4) show that the average rate of gain decreased as the calcium-phosphorus ratios in the rations became wider. When the average

TABLE 3. AVERAGE DAILY CALCIUM AND PHOSPHORUS CONSUMPTION (GRAMS)

Lot number	1	2	3	4
Calcium				
Trial I	15.6	48.0	107.8	163.8
Trial II	15.7	53.2	105.2	155.3
Average	15.6	50.6	106.5	159.6
Phosphorus				
Trial I	11.8	11.7	11.8	11.8
Trial II	11.5	11.6	11.6	11.5
Average	11.6	11.6	11.7	11.6
Ratio of calcium phosphorus				
Trial I	1.3–1.0	4.1–1.0	9.1–1.0	13.9–1.0
Trial II	1.4–1.0	4.6–1.0	9.1–1.0	13.5–1.0
Average	1.4–1.0	4.4–1.0	9.1–1.0	13.7–1.0

TABLE 4. THE AVERAGE DAILY GAINS PER HEAD FOR THE TWO TRIALS

Lot Number	1	2	3	4	
Ca-P Ratio	1.34–1	4.34–1	9.10–1	13.70–1	Average
			lb.		
Trial I	1.31	1.22	1.11	1.08	1.18
Trial II	1.35	1.38	1.15	1.13	1.25
Average	1.33	1.30	1.13	1.10	1.22

total gains per calf for the two trials were analyzed statistically (Snedecor, 1946) the differences among treatments were highly significant (table 5). The year-treatment interaction was not statistically significant.

The average daily gains made by the calves that were fed rations which furnished calcium-phosphorus ratios of 1.3:1.0 (lot 1) and 4.3:1.0 (lot 2) did not differ greatly. Further, the average daily gains made by the calves that were fed rations which furnished calcium-phosphorus ratios of 9.1:1.0 (lot 3) and 13.7:1.0 (lot 4) did not differ greatly. However, the average daily gains made by the steers in lots 1 and 2 did differ rather widely from the average daily gains made by the steers in lots 3 and 4. This is an indication that a critical calcium-phosphorus ratio for growing calves may exist between 4.3:1 and 9.1:1. Lamb *et al.* (1934) fed dairy heifers rations in which the calcium-phosphorus ratios varied from 3.7:1 to 6.5:1. They reported that the wider calcium-phosphorus ratio did not appear to affect the efficient utilization of phosphorus under the conditions of the experiment. In view of the findings of Lamb *et al.* and the results reported here, a critical calcium-phosphorus ratio, if such exists for growing calves, would fall between 6.5:1 and 9.1:1.

The excess calcium fed as ground limestone in this experiment may have interferred with the absorption and utilization of phosphorus and possibly other essential minerals; or it may have depressed the digestibility of other nutrients in the rations. Colovos *et al.* (1952) reported that feeding ground limestone at the rate of 100 gm. per day to dairy heifers, 12 to 18 months of age, caused a drop of 6 to 8% in the digestibility of the protein in the silage fed. Colovos *et al.* (1953, '54) fed limestone at the rate of 0, 50 and

TABLE 5. ANALYSIS OF VARIANCE OF TOTAL POUNDS OF GAIN PER HEAD

Source	D F	SS	MS	F
Total	75	75,758.35		
Years	1	1,939.20	1,939.20	2.31
Treatments	3	14,210.66	4,736.89	5.64**
Error	71	59,608.49	839.56	

** Significant at the 1% level.

100 gm. per head daily with silage to dairy heifers. Adding 50 gm. of limestone per head daily did not significantly affect the digestibility of the protein and energy in the rations. However, feeding 100 gm. of limestone per head daily did significantly lower the digestibility of both the protein and the energy in the rations. Colvos *et al.* (1955) studied the effects of pulverized limestone and dicalcium phosphate on the digestibility and utilization of protein and energy of a ration fed to dairy heifers. The addition of 2% limestone to the basal ration decreased the digestibility of both protein and energy, confirming their previous results. The addition of 2% dicalcium phosphate to the basal ration did not have any appreciable effect. The addition of 2% dicalcium phosphate with the 2% limestone minimized the depressing effect of the limestone.

Lewis *et al.* (1951) reported that the feed consumed by steer calves per 100 lb. of body weight and the rate of gain were reduced by borderline or deficient phosphorus intakes, and that excess calcium added to a ration of borderline phosphorus content further reduced both feed consumption and rate of gain. However, when excess calcium was added to a phosphorus-deficient ration, feed consumption was decreased, but rate of gain was not affected.

Haag *et al.* (1932) reported the results from a series of metabolism studies in which the nitrogen, calcium and phosphorus balances of dairy cows were determined for 16 five-day periods, during which the daily milk yield varied from approximately 10.5 to 15.0 kg. Supplementing the basal ration with calcium carbonate did not appear to affect the storage of either calcium or phosphorus. These workers concluded that the failure of calcium carbonate in depressing phosphorus retention apparently means that a calcium-phosphorus ratio of 10.5:1 was no more detrimental than one of 7.6:1. These workers stated that this does not necessarily mean that such rations are without detrimental effects, but does indicate that under certain conditions, at least, such ratios may be quite high without producing nutritional disaster.

Feed consumption and utilization. The average daily consumption of prairie hay which was fed ad libitum was approximately equal for all lots. The pound of soybean oil meal and 4 lb. of corn fed per calf daily were all consumed without weighback. Thus, the limestone fed in lots 2, 3 and 4 did not depress the calves appetites for roughage in this experiment.

The feed required per 100 lb. of gain increased as the calcium in the rations was increased and as the calcium-phosphorus ratios became wider. This is an indication that the excess calcium may have interfered with the utilization of the nutrients in those rations. Since feed required per 100 lb. of gain is a function of both total gain and total feed consumption it was to be expected that a depression of gain without a depression of feed consumption would result in a lowered apparent efficiency of feed utilization. However, the lower efficiency of feed utilization observed in

this experiment is in line with the lower digestibility of protein and energy observed by Colovos *et al.* (1952, '53, '54 and '55).

Blood studies. Haag *et al.* (1932), in a series of metabolism trials, fed lactating dairy cows rations which furnished calcium-phosphorus ratios of 10.5:1. The high level of calcium did not depress phosphorus retention. Lewis *et al.* (1951) fed steer calves rations that furnished excess calcium and either borderline or adequate phosphorus. They reported that the phosphorus plasma levels were related in a general way to the phosphorus intake, but the calcium plasma levels showed a characteristic fluctuation which was unaffected by treatments or by phosphorus plasma levels.

The initial and terminal plasma calcium and inorganic phosphorus levels were determined for all calves in trial I. In trial II initial and terminal

TABLE 6. AVERAGE CALCIUM AND INORGANIC PHOSPHORUS PER 100 ML. OF BLOOD PLASMA (MG.)

Lot number	1		2		3		4	
Ca – P ratio	1.34–1.0		4.34–1.0		9.10–1.0		13.70–1.0	
	Calcium							
	Initial	Terminal	Initial	Terminal	Initial	Terminal	Initial	Terminal
Trial I	11.3	10.3	11.3	11.1	11.2	10.7	11.1	11.4
Trial II	10.8	9.7	....	....	....	....	11.1	8.8
	Phosphorus							
Trial I	8.6	7.3	8.2	7.0	8.8	7.1	8.9	6.2
Trial II	8.2	8.6	....	....	....	....	8.1	8.1

plasma calcium and inorganic phosphorus levels were determined for the calves in only lots 1 and 4. The average levels of calcium and inorganic phosphorus in the blood plasma are presented in table 6.

The initial and terminal plasma levels of calcium and inorganic phosphorus (table 6) are within the ranges that have been reported as normal for cattle. Savage and Heller (1947) found that calcium varied from 9.9 mg. per 100 ml. of plasma to 11.3 mg. with a yearly average of 10.7 mg. The inorganic phosphorus content of the plasma varied from 4.3 mg. per 100 ml. to 7.5 mg. with a yearly average of 5.8 mg. Knox *et al.* (1941) working with beef cows reported a range of 10.6 mg. to 12.8 mg. of calcium per 100 ml. of plasma, and 1.4 mg. to 4.9 mg. of inorganic phosphorus per 100 ml. of plasma. Lamb *et al.* (1934) reported calcium levels ranging from 10.2 mg. to 10.8 mg. and phosphorus levels ranging from 6.30 mg. to 6.57 mg. per 100 ml. of plasma for dairy heifers before calving.

The initial and terminal calcium and phosphorus levels were subjected to an analysis of variance between treatments within trials, table 7. There were no statistically significant differences between treatments in initial plasma levels of either calcium or phosphorus. This was to be expected

TABLE 7. ANALYSIS OF VARIANCE MG. OF CALCIUM AND INORGANIC PHOSPHORUS PER 100 ML. OF BLOOD PLASMA

		Trial I											
		Calcium						Phosphorus					
		Initial			Terminal			Initial			Terminal		
Source	DF	ss	ms	F	ss	ms	F	ss	ms	F	ss	ms	F
Total	39	51.87			55.85			33.29			29.66		
Treatment	3	0.36	0.12	0.083	1.82	0.61	0.41	2.74	0.913	1.08	6.91	2.30	3.64*
Error	6	51.51	1.43		54.03	1.50		30.55	0.849		22.75	0.60	
		Trial II											
Source	DF	ss	ms	F	ss	ms	F	ss	ms	F	ss	ms	F
Total	17	8.82			2.02			30.48			10.94		
Treatments	1	0.56	0.56	1.08	0.07	0.07	0.58	0.08	0.08	0.042	1.28	1.28	2.13
Error	16	8.26	0.52		1.95	0.12		30.40	1.90		9.66	0.60	

* Significant at the 5% level.

because of the similar backgrounds of the calves. The terminal calcium levels did not differ significantly between treatments. Even though excesses of calcium were fed, these excesses were not reflected in the blood plasma. In trial I the terminal phosphorus levels did differ significantly between treatments, in trial II they did not. In trial I it appeared that the excess calcium may have in some way affected phosphorus absorption and/or utilization, however, in trial II this effect was not observed.

The average inorganic phosphorus per 100 ml. of blood plasma did not fall below 6.2 mg. for any of the lots, (table 6). This is above the level considered adequate for normal nutrition (Knox *et al.*, 1941; Savage and Heller, 1947; Lamb *et al.*, 1934). Palmer and Eckles (1927) and Green and DuToit (1927) reported that the blood of cattle suffering from phosphorus deficiency is low in inorganic phosphorus. Henderson and Weakley (1930) and Huffman *et al.* (1933) reported that a low concentration of inorganic phosphorus in the blood plasma is an indication of a ration deficient in phosphorus. Stanley (1938) reported that blood phosphorus levels consistently below 5 mg. per 100 ml. of blood serum are usually a definite indication of a lack of available phosphorus in the feed. W. H. Black, as quoted by Savage and Heller (1947) considered 4 mg. of phosphorus per 100 ml. of blood serum to be the danger point for two-year old steers. Thus, the excess calcium fed in this experiment did not depress plasma phosphorus below a level that could be considered adequate for normal nutrition on the basis of previous work. This might be considered as further circumstantial evidence that the excess calcium depressed gains by interferring with the digestibility and/or absorption of nutrients and mineral elements other than phosphorus. This is in agreement with the findings of Colovos *et al.* (1952, '53, '54, '55).

Summary

Two 140-day feeding trials were conducted to compare the effects of adequate calcium with excess calcium on the performance of beef calves fed adequate phosphorus in a growing ration.

Calcium-phosphorus ratios of 1.3:1, 4.3:1, 9.1:1, and 13.7:1 were fed to steer calves in lots 1, 2, 3 and 4, respectively. The phosphorus fed in all lots was approximately 12 gm. per calf daily. Calcium in the rations was varied by adding ground limestone. The calves in all lots consumed about the same amount of feed per day.

Gains decreased as the calcium in the rations was increased. The average gains made by the calves in lots 1 and 2 did not differ greatly and the average gains made by the calves in lots 3 and 4 did not differ greatly. However, the average gains made by the calves in lots 1 and 2 did differ widely from the gains made by the calves in lots 3 and 4. Thus, if gains are used as a criterion, a critical calcium-phosphorus ratio may exist between 4.3:1 and 9.1:1.

Initial and terminal calcium and inorganic phosphorus levels in the blood plasma were determined for all calves in trial I and for the calves from lot 1 and lot 4 in trial II. The excess calcium intake was not reflected by a change in the blood plasma calcium levels. In trial I, the terminal inorganic phosphorus in the plasma differ significantly between treatments. In trial II, the inorganic phosphorus in the plasma did not differ significantly between the lots. The inorganic phosphorus content was not depressed below a level considered adequate for proper nutrition. Thus, the excess calcium appeared to depress gains by interferring with the digestibility and/or absorption of nutrients and mineral elements other than phosphorus.

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EFFECT OF FEEDING STILBESTROL AND UREA ON RATION DIGESTIBILITY AND ON RETENTION OF CALCIUM, PHOSPHORUS, AND NITROGEN IN LAMBS [1]

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CONSIDERABLE information may be derived from the use of digestion and balance studies in determining the effect of ration substitutes and additives on the utilization of feed nutrients by farm livestock. The search for economical feed nutrients and feed additives is continuing in an effort to lower production costs. In using farm grown feedstuffs, protein is the nutrient most apt to be lacking to properly balance rations for livestock. Synthetic urea has been effectively used as a partial protein substitute for ruminants for a number of years (Reid, 1953; Gallup *et al.*, 1953; and Bell *et al.*, 1953). More recently stilbestrol feeding has been used to increase the rate of gain and feed efficiency of ruminants (Burroughs *et al.*, 1954). Light *et al.* (1956) fed urea and stilbestrol to fattening lambs, however there is little information regarding the metabolic action of stilbestrol and its effect on urea utilization.

These digestion and balance studies were conducted to determine the effect of adding stilbestrol to fattening type rations for lambs fed either urea or cottonseed meal as a protein supplement.

Experimental Procedure

From a group of 16 wethers, 12 averaging 97 lb. each were selected and placed in individual stanchions for 14 days to accustom them to their new environment. At the end of this period, the wethers were divided into four lots based on weight and uniformity and placed in metabolism stalls which were a modification of the stalls described by Briggs and Gallup (1949). The experimental period was divided into six consecutive 7-day trials. The urine and feces were collected daily during four of these trials (1, 2, 5 and 6). During trials 3 and 4, the wethers were removed from the metabolism stalls and individual feeding continued on the same rations fed during trial 2. One of the wethers in lot 1 was replaced due to low feed consumption and lameness in the front feet. The wethers were weighed at the beginning and end of each trial. During the entire experiment, lots I and II were fed 1 lb. of hay and 1.25 lb. of corn and cottonseed meal.

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mixture per head daily, and lots 3 and 4 were fed 1 lb. of hay and 1.25 lb. of corn and urea mixture. During trial 2 through trial 5, lots II and IV were fed in addition 4 mg. of stilbestrol per head daily with the grain mixture. Lots I and III were fed the same feed throughout the entire experiment.

The wethers were fed a constant amount of experimental ration at the same time each day. Samples of feed and orts were collected, composited and analyzed in order to determine the intake of the different nutrients by each lamb. During the collection trials, urine and feces were quantitatively collected daily. Ten percent aliquots of urine and feces were taken daily, refrigerated, then composited at the end of each trial. In addition

TABLE 1. AVERAGE PERCENTAGE COMPOSITION OF HAY AND GRAIN MIXTURES

Feed	Dry matter	Crude protein	Ether extract	Crude fiber	NFE	Ash
	%	%	%	%	%	%
Mixed grass hay	90.8	9.3	1.3	35.4	39.9	4.9
Corn, cottonseed meal (mixture 1)	87.8	13.4	4.2	2.5	64.9	2.8
Corn, urea (mixture 2)	87.5	13.5	3.5	1.6	66.5	2.4

to the 7-day composite sample, a daily sample of urine and feces was taken during trials 2 and 6 for the determination of nitrogen excretion only. Nitrogen was determined on wet fecal samples while all other analyses were conducted on dry fecal samples. From the 7-day composite, samples of feces and urine were taken and analyzed for calcium, phosphorus and nitrogen. Coefficients of apparent digestibility were calculated for crude fiber, crude protein, nitrogen free extract and ether extract. For the same four trials, balance studies for calcium, phosphorus and nitrogen were conducted.

Proximate analyses were made by A.O.A.C. Methods (1950) or by a slight modification of these methods. Calcium analysis was determined by a modification of the method of Brown *et al.* (1950), and phosphorus was determined by a modification of the method of Fiske and Subbarow (1925). Statistical analyses were made according to procedures listed by Snedecor (1946). Table I shows the average percentage composition of the hay and grain mixtures. The percentages of the feed ingredients in the grain mixtures are shown in table 2.

Results and Discussion

The results of this experiment are summarized in tables 3 and 4. There was a significantly greater digestibility of crude protein and a significantly

lower digestibility of ether extract from the rations containing the urea compared with the cottonseed meal rations (table 3). The stilbestrol had no apparent effect upon the digestibility of the ration nutrients; this is in agreement with results obtained by Whitehair *et al.* (1953) who used stilbestrol implants and Acker *et al.* (1955) who fed stilbestrol.

Data in table 4 show that the feeding of stilbestrol significantly increased the daily nitrogen retention during the first seven days (4.88 vs. 3.28 gm). The greater retention continued as long as the wethers received the stilbestrol. This is in agreement with data presented by Whitehair *et al.* (1953) and Clegg and Cole (1954), who found that stilbestrol implants increased nitrogen retention. This increased retention of nitrogen,

TABLE 2. GRAIN MIXTURES

Ingredient	Mixture 1	Mixture 2
	lb.	lb.
Corn	85.5	96.85
Cottonseed meal	13.0	—
Urea	—	1.65
Calcium carbonate	1.0	1.00
Salt	0.5	0.50
Total	100.0	100.00

when wethers were fed stilbestrol, was found to be due to a decrease in the amount of nitrogen excreted in the urine. Stilbestrol increased nitrogen retention when fed with either urea or with cottonseed meal. With the addition of stilbestrol, the increase in nitrogen retention was immediate (table 4). These results indicate that stilbestrol had an immediate effect on nitrogen retention, but had a delayed effect upon the metabolism of calcium and phosphorus. In trial 5, after the wethers had been receiving stilbestrol for four weeks, the nitrogen balance was 4.92 gm. compared with 3.02 for the controls. After discontinuing the stilbestrol treatment at the end of trial 5, nitrogen balance remained higher than the control groups during trial 6.

Considerable variation occurred in the calcium balance during the first two trials with no statistically significant differences. In trial 5, lots II and IV showed a significant increase in the retention of calcium when stilbestrol had been fed for a period of 28 days. This indicates a continued build-up effect. Trial 6 for lots II and IV shows that the calcium balance was significantly higher than the averages of lots I and III, the control groups. However, the calcium retention was reduced considerably as compared with the previous seven days. These results indicate a carry-over effect after

TABLE 3. AVERAGE APPARENT COEFFICIENTS OF DIGESTIBILITY OF EXPERIMENTAL RATIONS

Protein supplement	Trial number	Lot no.	Dry matter		Crude protein		Ether extract		Crude fiber		NFE	
			I	II	I	II	I	II	I	II	I	II
Cottonseed meal	1		71.0	71.5	57.3	61.6	83.4	83.3	45.1	46.8	82.0	82.7
	2		71.5	73.0[a]	64.6	66.8[a]	86.9	86.4[a]	47.4	46.6[a]	81.4	82.2[a]
	5		72.0	69.7[a]	65.3	66.8[a]	80.1	86.4[a]	51.5	46.6[a]	81.4	82.2[a]
	6		71.0	73.0	63.5	68.3	80.9	81.8	50.3	57.7	81.4	83.4
	Average		71.4	71.8	62.7	65.9	83.1	84.5	48.6	49.4	81.6	82.6
Urea		Lot no.	III	IV	III	IV	III	IV	III	IV	III	IV
	1		74.0	73.5	69.5	65.5	83.0	79.9	51.5	49.7	82.9	82.4
	2		72.5	73.0[a]	72.9	69.8[a]	78.3	82.8[a]	47.5	46.3[a]	81.7	82.4[a]
	5		71.5	71.0[a]	69.2	68.6[a]	76.1	72.6[a]	43.1	49.0[a]	82.2	80.6[a]
	6		76.5	75.5	73.3	71.3	82.1	80.6	50.2	57.0	86.2	83.8
	Average		73.6	73.2	71.2	68.8**	79.9	79.0**	48.1	50.5	83.2	82.3

[a] Each lamb received 4 mg. stilbestrol fed daily.
** $P<0.01$.

TABLE 4. AVERAGE DAILY NITROGEN, CALCIUM AND PHOSPHORUS BALANCE FOR WETHERS

Lot number	Trial number	Number of animals	Intake	Excretion		Total excretion	Balance
				Urine	Feces		
			Nitrogen				
I & III	1	4	16.48	8.96	5.96	14.92	1.56
	2	4	18.50	9.44	5.78	15.22	3.28
	5	4	17.76	8.90	5.84	14.74	3.02
	6	4	17.94	8.67	5.69	14.36	3.58
	Average		17.68	9.00	5.82	14.82	2.86
II & IV	1	8	17.28	8.67	6.30	14.97	2.31
	2[a]	8	18.44	7.74	5.82	13.56	4.88**
	5[a]	8	19.15	8.06	6.17	14.23	4.92
	6	8	18.39	8.52	5.56	14.08	4.31
	Average		18.32	8.25	5.96	14.21	4.11
			Calcium				
I & III	1	4	2.46	.06	2.32	2.38	.08
	2	4	2.51	.04	2.42	2.46	.05
	5	4	2.57	.02	1.98	2.00	.57
	6	4	2.31	.05	2.18	2.23	.08
	Average		2.46	.04	2.22	2.26	.20
II & IV	1	8	2.86	.04	2.21	2.25	.61
	2[a]	8	2.33	.03	2.12	2.15	.18
	5[a]	8	2.92	.01	1.59	1.60	1.32**
	6	8	2.38	.02	1.86	1.88	.50**
	Average		2.62	.03	1.94	1.97	.65
			Phosphorus				
I & III	1	4	2.04	.01	2.09	2.10	—.06
	2	4	2.16	.01	2.10	2.11	.06
	5	4	2.14	.02	1.80	1.82	.32
	6	4	2.18	.01	1.99	2.00	.18
	Average		2.13	.02	2.00	2.01	.12
II & IV	1	8	2.16	.01	2.11	2.12	.04
	2[a]	8	2.09	.01	1.98	1.99	.10
	5[a]	8	2.35	.02	1.27	1.29	1.06**
	6	8	2.26	.02	1.62	1.64	.62**
	Average		2.22	.01	1.75	1.76	.46

[a] Stilbestrol fed at the rate of 4 mg. per day.
** $P<0.01$.

discontinuing stilbestrol in the ration. Very little calcium was excreted in the urine and the extra calcium retention was due to a reduction in fecal excretion of calcium.

Results with phosphorus for the four trials followed the same pattern as calcium. Statistical analysis of these data showed that urea compared to cottonseed meal did not have any effect upon the retention of calcium or phosphorus during the 42-day period of the experiment; therefore, these data were pooled. A significant increase in the retention of phosphorus

by lots II and IV, (1.06 gm.) over lots I and III, (.32gm.) occurred in trial 5. This effect was also carried over into trial 6 after stilbestrol feeding was discontinued.

The greater retention of nitrogen, calcium and phosphorus when fed stilbestrol suggests that the animals were able to utilize these nutrients more efficiently, making faster bone and body growth and thus, reaching market weight sooner than with normal feeding. These data along with the data showing greater water and less fat content of the tissues of ruminants fed stilbestrol as shown by Wilkinson *et al.* (1955), indicate a stimulation to growth. A greater storage of minerals, water and nitrogen occurs during normal growth as compared to fattening.

When the wethers first received stilbestrol, they became nervous and excitable, however they began to clean up their feed more regularly during this period. This is in agreement with observations of Whitehair *et al.* (1953). The animals on stilbestrol showed signs of some swelling around the rectum. It was also noticed during the fourth and fifth trials that the teats of these whethers had lengthened, and the teats of two animals contained a fluid substance similar in appearance to milk.

Summary

Twelve wethers fed a fattening-type ration were used in a series of digestion and balance trials to study the effect of adding stilbestrol to a ration containing either urea or cottonseed meal as a protein supplement. This study was divided into six 7-day periods with standard urinary and fecal collections taken during the first, second, fifth and sixth periods.

A significantly greater digestibility of crude protein and significantly lower digestibility of ether extract were found for lambs fed rations containing urea as compared with those fed rations containing cottonseed meal. Urea feeding showed no noticeable effect on the retention of calcium, phosphorus or nitrogen. Stilbestrol feeding had no significant effect on the digestibility of ration nutrients. The feeding of stilbestrol significantly increased the daily nitrogen retention during the first seven days (4.9 vs. 3.3 gm.), and there was a higher but non-significant carry-over effect during the 7-day period after stilbestrol feeding was discontinued. Stilbestrol feeding significantly increased calcium and phosphorus retention during the last seven days (1.3 vs. 0.3 gm. for phosphorus), and there was a significant carry-over effect for seven days after stilbestrol feeding was stopped. These results show that urea is utilized by ruminants and that stilbestrol feeding, under the conditions of this metabolism test, increased the retention of calcium, phosphorus and nitrogen by lambs.

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EFFECTS OF FAT, OXYTETRACYCLINE, AND STILBESTROL ON PERFORMANCE AND HEPATIC STORES OF CAROTENE AND VITAMIN A IN STEERS

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THE use of fat in the ration of poultry and swine is an accepted means of increasing the energy intake. However, fat cannot be incorporated as readily in the ruminant's ration without considering the type of ration with which the fat is to be fed. The addition of a high level of fat (7%) to rations containing 82% alfalfa hay increased rates of gain of yearling steers, whereas the average daily gain and digestibility of dry matter was reduced when the ration contained 82% wheat straw (Erwin *et al.*, 1956a, 1956b). Fat (animal grease) included in high-corn steer fattening rations at the rate of 0.5 lb. per steer daily increased rates of gain by .15 lb. daily. However, the addition of 1 lb. per steer daily resulted in no increase in rates of gain (Matsushima *et al.*, 1956).

Oxytetracycline has been shown to accelerate weight increase in young dairy calves (MacKay *et al.*, 1953; Kesler, 1954). Results indicate that oxytetracycline also increases rate of gain in this specie (Hale *et al.*, 1957). Limited data are available on the effects of oxytetracycline in rations for fattening steers.

Stilbestrol has been fed with success in many areas under a wide range of conditions. (Burroughs *et al.*, 1956; Beeson *et al.*, 1956; Erwin *et al.*, 1956 and others).

The objectives of this experiment were to study the effect of fat, oxytetracycline and stilbestrol on beef cattle consuming feeds indigenous to the Northwest. Criteria for evaluating the supplements with this ration were weight gains, feed efficiency, hepatic vitamin A and carotene storage, and digestibility of dry matter, crude fiber and crude protein.

Procedure

The first experiment consisted of 18 yearling Hereford steers that were allotted according to weight into 6 groups of 3 each and individually hand-fed for 86 days. Steers were fed an all-pelleted ration (table 1) in which fat (bleachable fancy tallow), oxytetracycline and stilbestrol were the variables. Seven per cent fat replaced 7% barley in rations 2 and 6.

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Oxytetracycline and stilbestrol were added as 5 and 0.5 mg. per pound of ration, respectively. Individual weights were recorded at 28-day intervals.

After termination of phase one and a 10-day adjustment period, steers were re-allotted into 6 groups of 3 steers each. Allotments were such that no steer remained on the same ration. The rations used had the same composition and variables as described in the first phase.

Weight gains and feed consumption data were recorded at 28-day intervals. Digestibilty of dry matter, crude fiber and crude protein were de-

TABLE 1. EXPERIMENT 1, EFFECTS OF INDIVIDUALLY FEEDING RATIONS CONTAINING FAT, OXYTETRACYCLINE AND STILBESTROL ON PERFORMANCE OF YEARLING STEERS

	Lot numbers and treatment					
	1	2	3	4	5	6
	Basal [a]	Treatment 1 +fat [b]	1+Oxytetracycline [c]	1+ Stilbestrol [d]	1+ Oxytetracycline+ stilbestrol	1+fat+ oxytetracycline
No. of steers per group	3	3	3	3	3	3
Av. initial weight, lb.	563	608	619	565	585	545
Days on test	86	86	86	86	86	86[e]
Total gain per steer, lb.	117	140	179	177	215	123
Av. daily gain, lb.	1.35	1.63	2.08	2.05	2.50	1.62
Av. daily feed per steer, lb.	11.7	10.4	12.7	11.7	12.5	10.0
Total feed per steer, lb.	1006	894	1092	1006	1075	860
Gain produced per 100 lb. feed consumed, lb.	11.6	15.7	16.4	17.6	20.0	14.3

[a] The all-pelleted basal ration contained the following ingredients: 26% barley, 30% oats, 15% beet pulp, 20% alfalfa, 4% cottonseed meal, 4% molasses and 1% salt.
[b] 7% fat replaced 7% barley.
[c] 5 mg. per pound of feed.
[d] 0.5 mg. per pound of feed.
[e] One animal died of bloat the 56th day on test.

termined by the total collection method. Carotene and vitamin A contents of the feed and liver were determined according to the method of Gallup and Hoefer (1946). Analysis of variance was used to test for significance among treatments.

Results and Discussion

Results of trials 1 and 2 are presented in tables 1 and 2, respectively. In experiment 1, rates of gain were increased significantly ($P<.05$) by supplementing the basal ration with either oxytetracycline, stilbestrol, oxytetracycline and stilbestrol or fat and oxytetracycline. The increase in gain as a result of adding fat approached significance at the 5% level.

The low rates of gain in all groups were due to the low feed intake. Either frequent handling, unpalatable feed or both could have caused the low feed intake.

The feed consumption in all lots was lower than the approximately 18 lb. per head daily recommended by the National Research Council's Recom-

TABLE 2. EXPERIMENT 2, EFFECTS OF FAT, OXYTETRACYCLINE AND STILBESTROL ON PERFORMANCE OF YEARLING STEERS

	Lot numbers and treatment					
	1	2	3	4	5	6
	Basal [a]	1+Fat	1+ Oxytetra-cycline	1+Stil-bestrol	1+Oxy-tetra-cycline +stil-bestrol	1+Fat +oxy-tetra-cycline
No. of steers per group	3	3	3	3	3	3
Av. initial wt., lb.[b]	709	796	806	824	831	789
Days on test	78	78[c]	78	78	78	78[c]
Total gain per steer, lb.	135	122	181	186	192	104
Av. daily gain, lb.	1.74	1.56	2.32*	2.39*	2.46*	1.33
Av. daily feed, lb.	15.5	15.3	19.7	18.8	19.0	13.0
Gain produced per 100 lb. feed consumed, lb.	11.2	10.2	11.8	12.7	13.0	10.3
Av. digestibility,						
dry matter, %	68.8	61.9	70.1	69.3	71.3	60.8
crude fiber, %	51.0	39.9	49.1	53.6	50.1	42.6
crude protein, %	68.2	66.1	71.3	70.3	68.3	74.2
Carotene, mcg./gm., fresh liver	2.96	3.51	3.23	4.78	3.86	4.59
Vitamin A, mcg./gm. fresh liver	3.08	3.78	7.78*	3.20	7.62*	3.56

* Gained significantly faster ($P<.05$) than group 1; significantly more ($P<.05$) vitamin A retained in liver.

[a] All treatments were as described in table 1.

[b] Because of previous treatment, animals could not be allotted so that the initial weights were equal.

[c] One animal died.

mended Nutrient Allowances for fattening steers of this weight. The overall low consumption was probably due to the finely ground, all-pelleted ration. An adjustment period of approximately 30 days was required to bring the steers on "full feed". The 7% fat in rations 2 and 6 further reduced the palatability of these rations. Rations 2 and 6 contained .73 and .70 lb., respectively, of supplemental fat per steer per day. These data coincide with those reported by Matsushima *et al.* (1956) in which 0.5 lb. of fat per steer per day increased rates of gain, but a level of 1 lb. per day merely increased feed efficiency. The efficiency of feed utilization was ex-

ceptionally high in group 5 (stilbestrol and oxytetracycline). This difference was statistically significant.

Because of the crumbling of pellets containing fat (groups 2 and 6) near the end of experiment 1, it was decided to re-pellet these rations and re-run the experiment. All steers were fed the basal ration for a 10-day adjustment period. Then the steers were re-allotted so that no animal remained on the same treatment as in experiment 1. Initial weights were not the same. However, an analysis of co-variance indicated that initial weight did not significantly influence subsequent rates of gain. In this re-run (experiment 2) feed consumption and subsequent rates of gain remained sub-optimal, perhaps because of either the finely ground, all-pelleted rations used, or the frequent handling required for individual feeding. The addition of either oxytetracycline, stilbestrol or oxytetracycline and stilbestrol significantly increased rates of gain. The feed efficiency was again highest in the oxytetracycline-stilbestrol fed group.

The digestibility of dry matter, crude fiber and crude protein was determined in the second experiment. The digestibility of crude protein was not affected by treatment. The digestibility of dry matter and crude fiber was reduced significantly ($P<.05$) when fat was added to the ration; however, other treatments neither increased nor decreased digestibility of these fractions.

Hepatic vitamin A was significantly higher as a result of feeding oxytetracycline. Observations by Burgess *et al.* (1951) with poultry indicate that penicillin increases hepatic retention of vitamin A. Similar work reported by Luther *et al.* (1952) indicates that either penicillin or chlortetracycline increases hepatic vitamin A retention in chicks. The latter workers also reported that oxytetracycline increased liver stores of vitamin A in the pig. The reasons for the increased retention of vitamin A in the presence of antibiotics is not understood. The inclusion of either fat or stilbestrol in the ration did not significantly influence hepatic levels of either carotene or vitamin A.

Summary and Conclusions

Results of two experiments are reported in which fat, oxytetracycline and stilbestrol were fed to yearling steers. The finely ground, all-pelleted rations with which these compounds were fed were not conducive to maximum feed consumption. Rates of gain were increased significantly by the incorporation of either oxytetracycline, stilbestrol or a combination of the two. In these experiments, fat fed at a high level (7% of the ration) did not significantly increase rates of gain, probably because of the accompanying reduction in digestibility of dry matter and crude fiber. Hepatic vitamin A levels were significantly higher in steers fed oxytetracycline.

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THE EFFECT OF CHLORTETRACYCLINE, STILBESTROL AND ANIMAL FAT ON FATTENING STEERS[1]

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THE value of antibiotics in the rations of beef cattle has been investigated to a limited extent only. Bell *et al.* (1951) reported that chlortetracycline had a detrimental effect upon steers when fed at a level of 200 to 600 mg. daily. Neumann *et al* (1951) fed lower levels of the antibiotic (2 mg. per lb. of feed) to fattening steers without any measurable effect. In 1954 Perry *et al.* reported that chlortetracycline increased the rate of gain of calves and yearlings when fed at the rate of 75 mg. daily. In more recent studies 5 mg. chlortetracycline per lb. of feed increased the rate of gain of fattening steers regardless of whether the roughage was alfalfa or wheat straw (Erwin *et al.*, 1956).

Burroughs *et al.* (1954a, 1954b, 1955) have reported that stilbestrol, when fed to fattening steers at the rate of 10 mg. daily increased the rate of gain 10 to 35% and reduced the amount of feed required per unit of gain. No deleterious side effects of stilbestrol were noticed. Bell *et al.* (1954), Deans *et al.* (1956), Luther *et al.* (1954) and others have reported similar results.

Little information is available concerning the desirable or optimum level of fat in the rations of fattening beef cattle. Jones (1942) compared the value of cottonseed meal, cottonseed meal supplemented with cottonseed oil and whole cottonseed and found that the additional fat in whole cottonseed and cottonseed meal plus oil increased the rate of gain and yield of dressed beef beyond that obtained with cottonseed meal alone. Willey *et al.* (1952) added 5% cottonseed oil and Matsushima and Dowe (1954a) added 5% beef tallow to rations of fattening steers and increased the efficiency of feed utilization, but the high fat rations had no effect on rate of gain. Hentges *et al.* (1954) fed 5% raw tallow to fattening steers and increased the rate of gain in one trial. In a second trial this level of fat had little effect while 10% added fat markedly reduced the rate of gain. In both trials less feed was required per unit of gain when fat was fed. Erwin *et al.* (1956) found that fat increased the rate of gain of steers consuming alfalfa as the basal roughage but reduced the rate of gain of steers fed straw.

The purposes of this experiment were: (1) to obtain additional information on the use of chlortetracycline and stilbestrol for fattening beef cattle,

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[2] Department of Animal Husbandry.

(2) to determine the optimum level of fat in their rations and (3) to determine the interactions between these constituents.

Experimental Procedure

Forty-eight steers approximately 2 years of age were allotted at random to treatments in a $2\times2\times3$ factorial designed experiment. The experimental treatments were: 2 levels of chlortetracycline, 0 and 70 mg. daily; 2 levels of stilbestrol, 0 and 10 mg. daily; and 3 levels of added mixed animal fat, predominantly inedible beef tallow, 0, 5 and 10% of the ration. The basal ration was composed of alfalfa hay and a concentrate mixture of 25 parts rolled barley, 33 parts dried beet pulp, 42 parts ground milo, and 1 part

TABLE 1. THE CHEMICAL COMPOSITION OF THE RATION COMPONENTS

Feed	Dry matter	Composition of dry matter			
		Crude protein	Ether extract	Crude fiber	P
	%	%	%	%	
Alfalfa hay	93.0	15.0	2.3	36.4	0.19
Rolled barley	90.8	12.3	2.2	7.0	0.41
Ground milo	90.9	11.9	4.0	4.00	0.35
Dried beet pulp	93.4	8.2	0.04	19.5	0.07
			Melting point		Iodine no.
Mixed animal fat, predominantly inedible tallow			47° – 48° C		39.7

each of salt and steamed bone meal by weight. After the animals were on full feed, fat replaced equal parts of ground milo by weight at levels of 0, 10 and 20 parts of the concentrate mixture for the three experimental fat levels. Initially, the amount of animal fat in the rations was 0, 1 and 2%. At intervals of 2 or 3 days the percent fat was increased until the desired levels were reached, which occurred within 12 days. At all times the ratio of added fat in the concentrate mixtures was 1:2. In the preparation of the experimental rations, the fat was heated until fluid, mixed with the feed and fed within a period of 3 to 7 days after mixing. No antioxidant was used. An attempt was made to feed equal quantities of alfalfa and concentrates to each animal daily after the animals were brought up to full feed. After 60 days on experiment the proportion of dried beet pulp and ground milo were changed to 25 and 50 parts of the concentrate mixture, respectively. The chemical composition of the ration components is given in table 1. The steers were individually fed twice daily, but were maintained in groups of 12 between feeding periods. The experimental period was 119 days for half of the animals and 126 days for the rest. The steers were weighed at approximately 40-day intervals during the experiment. Feeder grades were taken initially and at 40 days after the

experiment began and slaughter grades were obtained at the end and 40 days prior to the end of the feeding period. Chlortetracycline and stilbestrol were individually hand-fed once daily to animals receiving these treatments from premixes that contained 7 gm. chlortetracycline and 1 gm. of stilbestrol per lb. Slaughter data were obtained at the termination of the experiment. All data were subjected to statistical analyses according to methods of Snedecor (1956) for factorial experiments. Two additional steers were fed similarly throughout the experiment; one was fed chlortetracycline and one without this additive. These animals were included in the statistical analyses for the occurrence of liver abscesses.

TABLE 2. THE EFFECT OF ANIMAL FAT ON FATTENING STEERS

Fat levels, % of total feed	0	5	10
No. of animals	16	16	16
Av. initial wt., lb.	774	770	776
Av. final wt., lb.	1021	1085*	1054
Av. daily gain, lb.	2.01	2.57**	2.27
Av. feed consumed daily, lb.			
Alfalfa	12.2	12.0	11.7
Concentrates	11.5	11.2	10.7
Av. feed per lb. gain, lb.			
Alfalfa	6.07	4.67**	5.15**
Concentrates	5.72	4.36**	4.71**
Total	11.79	9.03**	9.86**
Av. shrink enroute to market, % (10 mi.)	3.97	3.61	3.77
Av. cooler shrink, 72 hr. %	1.98	1.81	1.89
Av. terminal slaughter grade	G	G+	G+
Av. carcass grade	G+	CH—	CH—
Av. dressing %	61.4	61.4	60.5

*, ** Significantly different from the control ration, 0 level of fat, at the 5 and 1% level, respectively.

Results and Discussion

The effect of added fat on the growth and slaughter data is presented in table 2. The ration containing 5% animal fat increased the rate of gain 28% in this experiment ($P<.01$). The addition of 10% fat was not as effective as the lower level. In fact, gains of the animals fed this ration did not differ significantly from the control ration without added fat. Either level of added fat decreased the amount of feed required per pound of gain to the extent of 23 and 16% for the rations containing 5% and 10% fat, respectively ($P<.01$). These results are in contrast to those obtained by Willey *et al.* (1952) and Matsushima and Dowe (1954a). These investigators found that the addition of 5% fat had no effect upon the rate of gain but decreased the amount of feed required per unit of gain. In

the experiment reported in this paper 5% fat had an equally great effect upon rate as well as the economy of gain. In one trial Hentges *et al.* (1954) found that 5% fat increased the rate of gain, with fattening steers but in a second trial 5% fat had little effect and 10% fat markedly reduced the rate of gain.

It has been suggested that the type of roughage may influence the utilization of fat. Erwin *et al.* (1956) have shown that fat increased the rate of gain when fed with alfalfa but reduced the rate of gain when fed with straw. In the current study approximately 50% of the total feed was alfalfa which may account for the difference reported here and the results obtained by Willey *et al.* (1952) and Matsushima and Dowe (1954a). The effect of animal fat on the reduction of feed required per unit of gain is consistent with the results reported by other investigators (Willey *et al.*, 1952; Matsushima and Dowe, 1954a; Hentges *et al.*, 1954).

Recently Combs (1956) has reviewed numerous experiments concerning the relationship between protein and energy levels with growing poultry. He concluded that as the energy content of the ration increased, the percent of protein required for best feed efficiency and growth also increased. If this relationship is also applicable for ruminants, it would help explain some of the results of feeding relatively high levels of fat to this species. When fat has been added at relatively high levels (10%), the rate of gain has not been as great as when fat is fed at the 5% level (these data and Hentges *et al.*, 1954). Again one of the differences between various types of roughages is usually its protein content. When alfalfa was used as the basal roughage in the study of Erwin *et al.* (1956), the protein level was appreciably higher than when the ration contained wheat straw. The beneficial effects of the alfalfa-fat combination might then be explained on the basis of an improved calorie-protein ratio. When alfalfa supplies 50% or more of the ration for cattle, the protein requirement is usually greatly exceeded. Hence the beneficial results reported in this paper from the feeding of high levels of fat may be the result of a higher level of protein in the basal ration.

Fat had no significant effect on feed consumption, although there appeared to be a trend toward slightly less feed consumed daily with the addition of fat. The effect on appetite is of interest because the cattle were consuming on the average approximately 1 and 2 lb. of fat daily during the experiment for the rations containing 5 and 10% fat, respectively. No palatability problems were noted with any of the rations. It is of interest to note that all of the slaughter data with the exception of dressing percent appear to favor the rations containing fat but the differences are small and not statistically significant. The effects of chlortetracycline and stilbestrol on growth and slaughter data are given in table 3.

Stilbestrol increased the rate of gain 15% in this experiment and decreased the amount of feed required per lb. of gain the same amount

($P<.05$). Although the greatest observed rate of gain and lowest amount of feed required per unit of gain occurred when both chlortetracycline and stilbestrol were included in the ration, neither chlortetracycline or the interaction between chlortetracycline and stilbestrol were statistically significant. None of the treatments had any effect on shrink enroute to market, cooler shrink, dressing percentage, slaughter or carcass grades. This confirms the data previously reported by Burroughs *et al.* (1954a, 1954b, 1955). Chlortetracycline decreased the incidence of liver abscesses

TABLE 3. THE EFFECT OF CHLORTETRACYCLINE AND STILBESTROL ON FATTENING CATTLE

Feed additive	None	Chlor-tetracycline (70 mg. daily)	Stilbestrol (10 mg. daily)	Chlortetra-cycline and stilbestrol
No. of steers	12	12	12	12
Av. initial wt.	776	769	775	775
Av. final wt.	1036	1025	1053	1090
Av. daily gain, lb.	2.12	2.09	2.27	2.57
Av. daily feed consumed, lb.				
Alfalfa	12.2	11.6	11.8	12.1
Concentrates	11.3	10.9	10.9	11.2
Av. feed per lb. of gain, lb.				
Alfalfa	5.75	5.55	5.20	4.69
Concentrates	5.33	5.22	4.80	4.36
Total	11.08	10.77	10.00	9.05
Av. shrink enroute to market 10 mi., %	3.27	4.57	3.30	3.30
Av. cooler shrink, 72 hr., %	1.79	1.98	1.88	1.88
Av. terminal slaughter grade	G	G	G	CH—
Av. carcass grade	CH—	CH—	G+	CH
Av. dressing %	61.4	60.8	61.7	61.4
Liver abscesses	3	0[a]	3[a]	0

[a] Thirteen animals per group.

($P<.05$). This effect had been noted earlier by Matsushima *et al.* (1954b).

Stilbestrol reduced the amount of feed required per unit of gain in rations without animal fat; when fat was added, stilbestrol had no effect (table 4). This interaction was statistically significant. It is possible that the stilbestrol was dissolved in the dietary fat and excreted in the undigested fecal fat or soaps. This would explain the effect noted above although some other explanation may be equally feasible. Fecal estrogens were not determined. If fat interfered with the absorption of oral stilbestrol, it would also help explain the results of Erwin *et al.* (1956). These investigators fed stilbestrol to fattening steers without a significant growth response. Since half of their experimental cattle received animal fat, it might have

exerted a marked dampening effect on any expected growth response from stilbestrol.

Since the experiment was divided into three periods, the effect of the treatments on daily gain was investigated in each period. Stilbestrol and the intermediate level of animal fat increased the rate of gain significantly in the first two periods. Chlortetracycline increased the rate of gain significantly during the second period only. None of the treatments had any significant effect on rate of gain during the final period.

TABLE 4. THE EFFECT OF STILBESTROL AND ANIMAL FAT ON FEED ECONOMY

Item	Feed per lb. of gain, lb.			
	Alfalfa			
Fat levels, %	0	5	10	Av.
Control	6.92	4.73	5.28	5.64
Stilbestrol	5.24	4.59	5.03	4.95
Difference	1.68	0.14	0.25	0.69**
	Concentrates			
Control	6.45	4.48	4.85	5.26
Stilbestrol	4.95	4.21	4.55	4.57
Difference	1.50	0.27	0.30	0.69**

** Significant at P .01.

Summary

Chlortetracycline, stilbestrol and graded levels of animal fat were fed to fattening steers in a factorial experimental design. The addition of stilbestrol increased the rate of gain and reduced the amount of feed required per unit of gain. Five percent animal fat in the ration had a similar effect. Ten percent animal fat had no significant effect upon the rate of gain but reduced the amount of feed required per unit of gain in comparison to rations without added fat. Stilbestrol reduced the amount of feed required per unit of gain in rations without animal fat; when fat was added, stilbestrol had no effect. Chlortetracycline significantly increased the rate of gain in one period out of three. It also decreased the incidence of liver abscesses.

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THE EFFECT OF VARIOUS LEVELS OF STILBESTROL AND NOR-TESTOSTERONE IMPLANTS ON LAMB [1]

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PREVIOUS results obtained at this Station (Jordan and Croom, 1956) showed that implants of stilbestrol or combinations of estrogens and androgens consistently increased rate of gain, but caused a lowering in carcass grade and an enlargement of the accessory sex glands of wether lambs. Jordan (1953) reported equal growth stimulation in fattening lambs implanted with either 6 or 12 mg. of stilbestrol. The work reported here was conducted to compare the effects of lower levels of stilbestrol implants than previously reported and of four levels of a derivative of nor-testosterone (trade name Nilevar) on fattening lambs. Nilevar is manufactured from an estrogen but has no estrogenic activity as determined by both chemical and biological test. Its chemical structure has great similarity to methyl-testosterone.

Experimental Procedure

Three separate experiments were conducted during the fall, winter and spring of 1956–57. In all three studies the lambs were sheared prior to being placed on experiment and a fattening ration consisting of brome hay, shelled corn and protein supplement was hand-fed. The lambs were individually weighed and allotted according to their weight and sex. In the first trial conducted during the fall of 1956, an equal number of ewe and wether lambs were placed on each treatment. Only wether lambs were fed during the second and third trials conducted during the winter and spring of 1957. In the first trial the lambs in Lot 1, served as the control and the lambs in Lots 2 through 6, were implanted with 2, 3, 4, 5 or 6 mg. of stilbestrol per lamb, respectively. In the second trial the lambs in Lot 1, served as the control and the lambs in Lots 2 through 5, were implanted with 25, 50, 100 or 200 mg. of nor-testosterone per lamb, respectively. Each lamb in Lot 6, was implanted with 3 mg. of stilbestrol. In the third trial the lambs in Lot 1, served as the control and the lambs in Lots 2 through 5, were each implanted with 2, 3, 4 or 6 mg. of stilbestrol, respectively. Each lamb in Lot 6, was implanted with 50 mg. of nor-testosterone. In the second and third studies the hormone treatments were superimposed on another nutrition trial by implanting an equal number of lambs receiving each of the experi-

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[2] The Nilevar was donated through the courtesy of Francis J. Saunders of G. D. Searle and Company, Chicago, Illinois.

mental rations with each of the hormone treatments. Therefore, no feed consumption data could be gathered on those two trials. Individual carcass grade, carcass yield by lot and data pertinent to the effect of hormone treatment on the accessory sex glands of the wether lambs were gathered. Analysis of variance (Snedecor, 1946) was used for the statistical analysis of the data.

Results and Discussion

The results of trial 1, are presented in table 1, and the results of the second and third trials are presented in table 2.

TABLE 1. THE EFFECT OF STILBESTROL IMPLANTS ON FATTENING LAMBS—TRIAL 1

Treatment	Control [a]	2 mg. stil.	3 mg. stil.	4 mg. stil.	5 mg. stil.	6 mg. stil.
Number of lambs	14	14	14	14	14	14
Initial wt., lbs.	77.6	74.9	77.1	75.0	76.5	74.0
Final wt., lbs.	100.4	104.6	107.3	106.1	108.2	102.2
Number of days fed	62	62	62	62	62	62
Av. daily gain, lb.						
All lambs	.368	.479	.487	.502	.511	.455
Ewe lambs	.363	.423	.429	.392	.472	.435
Wether lambs	.372	.535	.542	.592	.560	.473
Av. daily feed consumption, lb.						
Grain	1.58	1.60	1.60	1.60	1.56	1.53
Hay	1.72	1.75	1.75	1.75	1.70	1.65
Protein supplement	.14	.14	.14	.14	.14	.14
Feed per 100 lb. gain, lb.						
Grain	429	333	328	318	304	336
Hay	468	365	360	350	333	363
Protein supplement	40	31	30	29	29	33
Carcass data						
Yield %	51.7	51.3	49.6	50.7	50.3	50.3
Grade [b]	8.0	7.8	7.6	7.7	7.8	7.2

[a] All the lambs were hand-fed a fattening ration of shelled corn, brome hay and soybean oil meal.
[b] Carcass grade code: Av. choice, 8; low choice, 7; high good, 6; etc.

Growth data. The implanting of stilbestrol, regardless of the level used, significantly increased the rate of gain ($P<.01$). The most rapid gain was made when 4 or 5 mg. of stilbestrol was used in the first trial, and when 4 or 6 mg. of stilbestrol was used in the third trial. However, the differences in response between levels of stilbestrol were not significant in either the first or third trial. Ewe lambs made significantly less response at the 2, 3, 4 and 5 mg. levels of stilbestrol than the wether lambs. However, when 6 mg. was implanted the difference in rate of gain between the ewe lambs and wether lambs was not significant. An equal increase in rate of gain has been reported when either 6 mg. or 12 mg.

stilbestrol were used (Jordan, 1953). Therefore, the data presented herein indicate that decidedly lower levels of stilbestrol implants may be employed in future research without reducing growth response. These decidedly lower levels of stilbestrol may make it economically possible to combine other hormones with stilbestrol at considerably lower than hertofore reported, thus minimizing the adverse physiological effects and lower carcass grades associated with 12 mg. stilbestrol implants and the correspondingly high levels of androgens and/or estrogens that have been combined with stilbestrol.

TABLE 2. THE EFFECT OF VARIOUS LEVELS OF STILBESTROL AND NOR-TESTOSTERONE IMPLANTS ON LAMBS—TRIAL 2

Lot No.	Treatment	Number lambs [a]	Initial wt.	Final wt.	Av. daily gain	Number days fed	Carcass data	
							Yield	Grade [b]
			lb.	lb.	lb.		%	
1	Control [c]	32	68.6	100.2	.451	70	52.1	7.3
2	25 mg. Nor-test.	11	77.4	104.1	.453	70	51.8	7.6
3	50 mg. Nor-test.	12	72.2	106.1	.484	70	52.0	7.5
4	100 mg. Nor-test.	11	70.8	98.8	.400	70	51.2	6.8
5	200 mg. Nor-test.	11	70.7	100.7	.429	70	51.7	6.3
6	3 mg. stilbestrol	12	71.6	111.0	.563	70	51.4	6.3
Trial 3								
1	Control [c]	12	78.8	113.9	.595	59	52.2	6.2
2	2 mg. stilbestrol	10	79.6	118.8	.664	59	52.0	5.5
3	3 mg. stilbestrol	11	78.7	118.2	.669	59	51.4	5.9
4	4 mg. stilbestrol	12	78.8	120.3	.703	59	51.0	5.6
5	6 mg. stilbestrol	10	80.7	122.4	.707	59	51.1	5.9
6	50 mg. Nort-test.	12	78.8	113.3	.585	59	51.5	5.7

[a] One lamb died of enterotoxemia in Lot 1, trial 2; and Lot 3, trial 3. One lamb was removed due to urinary blockage in Lot 2, trial 3; and two lambs removed due to urinary blockage in Lot 5, trial 3.

[b] Carcass grade code: Av. choice, 8; low choice, 7; high good, 6; etc.

[c] All the lambs were hand-fed a fattening ration of shelled corn, brome hay and protein supplement.

The implanting of a derivative of nor-testosterone caused a slight but nonsignificant increase in rate of gain at the 50 mg. level in the second trial, but this level had no effect in the third trial. In the second trial, either no effect on rate of gain or a slightly reduced rate of gain was observed when 25, 100 or 200 mg. of nor-testosterone was implanted.

Carcass data. Carcass yield was not affected by implants of stilbestrol regardless of the level used. No difference in carcass grade existed between the control lambs and the lambs treated with 2, 3, 4 or 5 mg. of stilbestrol in the first trial. However, carcass grade was slightly lower among the lambs treated with 6 mg. of stilbestrol. In the second trial the lambs that were implanted with 3 mg. of stilbestrol graded about one-third grade lower than the controls. In the third trial there was a tendency for all of the lambs that received various levels of stilbestrol to grade slightly lower than the control lambs. Most data reported from

this Station have shown that implants of 12 mg. have caused lower carcass grades. This depressing effect on carcass grade is usually most apparent in lambs that have been fed for a short period. It is interesting to note that there was no tendency for one level of stilbestrol to consistantly exert a greater depressing effect on carcass grade than another.

The lambs in all three studies were sold by lots. The packer-buyer was unable to detect differences in finish between lots and bought all of the lots at the same price within each trial. All of the lambs implanted with stilbestrol exhibited break joints even though the lambs in the third trial were not slaughtered until late April. Previous reports from this Station showed that implantation with 12 mg. of stilbestrol, 10 mg. estradiol plus 250 mg. progesterone or 2 mg. of oral stilbestrol per lamb daily caused closure of the break joint of lambs slaughtered in early May.

In the second trial the carcass grades of the lambs treated with 25 or 50 mg. of nor-testosterone were comparable to the control lambs. However, the lambs implanted with 100 or 200 mg. of nor-testosterone graded slightly lower than the controls. In the third trial the lambs treated with 50 mg. of nor-testosterone graded slightly lower than the control lambs.

Accessory sex glands. In all three trials the reproductive glands were collected on all of the wether lambs when slaughtered. Examination of this material showed a decided enlargement of the accessory sex glands in all wether lambs treated with stilbestrol, regardless of the level used. There was, however, a tendency for the higher levels of stilbestrol (5 and 6 mg.) to result in greater enlargement of these glands. No incidence of urinary blockage or prolapse of the rectum was evident among any of the lambs in the first and second trial. However, in the third trial one lamb which had been implanted with 2 mg. of stilbestrol developed a blockage of the urinary tract 8 days post-treatment. Upon post-mortem examination no calculi were found but a decided enlargement of the Cowper's gland and proliferation and enlargement of the prostate gland was observed. In this same study two lambs treated with 6 mg. of stilbestrol were removed due to a similar condition plus a prolapse of the rectum. This condition is similar to that previously reported by Bell *et al.* (1953), Jordan (1953) and Henneman *et al.* (1957). The irregular occurrence of this condition when stilbestrol is implanted suggests that other factors in the environment or the genetics of the lamb are interacting with the stilbestrol treatment. These data indicate that low levels of stilbestrol are not the answer to preventing the occurrence of urinary blockage and the relatively high death loss that accompanies this condition.

Implants of nor-testosterone, regardless of the level used, had no noticeable effect on the accesory sex glands.

Summary

Levels of 2, 3, 4, 5 or 6 mg. of stilbestrol were found to significantly increase rate of gain and feed efficiency of fattening lambs. Carcass yield was not affected by stilbestrol treatment. Carcass grade of the stilbestrol-implanted lambs tended to be slightly lower than those of the control lambs. Extreme enlargement of the accesory sex glands of all of the wether lambs was noted at the time they were slaughtered. During the feeding period one lamb receiving 2 mg. of stilbestrol and two lambs receiving 6 mg. of stilbestrol developed complete blockage of the urinary tract.

Implantation of 25, 50, 100 or 200 mg. of nor-testosterone resulted in no increase in rate of gain. No effect was noted on carcass grade or yield or on the accessory sex glands from this treatment.

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COMBINATION OF AN ANTIBIOTIC AND A FEMALE HORMONE FOR FATTENING STEERS [1]

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A NUMBER of research papers have shown the growth stimulatory effect of female hormone-like substances when fed to growing and fattening beef cattle (Andrews *et al.*, 1956; Beeson *et al.*, 1956; Burroughs *et al.*, 1954–1955; Perry *et al.*, 1955). Other materials which only very recently have been shown to be growth stimulatory to beef cattle are antibiotics (Beeson *et al.*, 1954, 1955).

Since the *modus operandi* of neither hormones nor antibiotics in stimulating growth rate in beef cattle has been elucidated, an approach to determining the effects of the two is to determine whether their effects are exerted complementary, independently or whether their effects are similar.

Experimental

Forty two-year-old Hereford steers averaging 925 lb. were divided into four lots of 10 steers each on the basis of liveweight and previous gain. The basal ration consisted of a full-feed of ground shelled corn, 2 lb. Purdue Supplement A,[2] legume silage *ad libitum* and minerals *ad libitum*.

Lot I served as the control and received the basal ration listed above. The three treated lots received, in addition to the basal ration, the following: Lot II, 12 mg. hexestrol per animal daily; Lot III, 100 mg. Aureomycin (chlortetracycline) per animal daily, and Lot IV, 12 mg. hexestrol and 100 mg. chlortetracycline per animal daily.

At the completion of the 84-day fattening trial, the four lots of cattle were followed through the marketing phase for obtaining comparative data on shrink-in-transit, dressing percent and U. S. Federal grades.

The twelfth rib was removed from one side of each carcass for individual chemical analyses of the attached meat.

Results and Discussion

Effect on growth rate. The feeding of the female hormone-like material, hexestrol, in the fattening ration of two-year-old steers resulted in a 24%

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[2] (Formula for Supplement A, 1000-lb. mix: soybean oil meal, 650 lb.; salt with cobalt, 17 lb.; vitamin A and D concentrate, 0.5 lb. (contains 4,540,000 U.S.P. units A and 567,500 U.S.P. units D per lb.)

increase in growth rate ($P<0.01$). The feeding of chlortetracycline also resulted in a 10% increase in growth rate. However, the combination of hexestrol and antibiotic resulted in a 37% increase in rate of gain ($P<0.01$) indicating the growth stimulatory effects of the two probably are independent and additive, but not necessarily complimentary. The growth accelerating effect of oral female hormone-like materials has been substantiated in other experiments (Andrews *et al.*, 1956); Beeson *et al.*, 1956; Burroughs *et al.*, 1955, 1954; Perry *et al.*, 1955). Apparently more than

TABLE 1. THE COMBINATION OF AN ANTIBIOTIC AND A FEMALE HORMONE FOR FATTENING STEERS

(103-Day Trial)

Item	Lot I Control	Lot II 12 mg. Hexestrol	Lot III 100 mg. chlortetracycline	Lot IV 100 mg. chlortetracycline 12 mg. hexestrol
Number of steers	10	10	10	10
		Growth rate, lb.		
Initial wt.	926	923	931	925
Final wt.	1137	1184	1163	1215
Total gain	211	261	232	290
Av. daily gain	2.03	2.50**	2.28*	2.79**
		Daily feed, lb.		
Corn	12.4	14.0	13.1	13.2
Supplement A	2.0	2.0	2.0	2.0
Legume silage	29.8	29.8	29.7	29.9
		Feed per 100 lb. gain, lb.		
Corn	609	562	574	474
Supplement A	97	80	87	72
Legume silage	1465	1191	1304	1071

* Least significant mean difference for gain—5% level, 26 lb.
** Least significant mean difference for gain—1% level, 35 lb.

one female hormone-like substance is effective in stimulating growth rate (Andrews *et al.*, 1956; Perry *et al.*, 1955). By far, the majority of the published data showing the growth stimulatory effect of female hormone-like materials has been with fattening rations containing higher levels of concentrates.

Conversely, the growth stimulatory effect of antibiotics has been shown when they are fed with rations that are predominately roughage materials (Perry *et al.*, 1954; Beeson *et al.*, 1955; Beeson and Perry, 1954). However, it should be pointed out that the growth stimulatory effect of antibiotics was exerted with high-roughage rations which were fattening rations (Beeson *et al.*, 1955; Beeson and Perry, 1954). Perry *et al.* (1954) reported no growth stimulation from the feeding of antibiotics in a high-grain

fattening ration. Adams *et al.* (1955) obtained growth increases from the feeding of an antibiotic with a high-corn ration that was almost as great as was that obtained from feeding diethylstilbestrol.

Adams *et al.* (1955) obtained growth stimulation from feeding a combination of diethylstilbestrol and the antibiotic, oxytetracycline, which was greater than that produced by either one alone. This is in line with the additive effect when the two were combined in the trial reported in this paper.

TABLE 2. EFFECT OF HEXESTROL AND AUREOMYCIN ALONE OR IN COMBINATION ON DRESSING PERCENT AND CARCASS GRADE

Item	Lot I Control	Lot II 12 mg. Hexestrol	Lot III 100 mg. chlortetracycline	Lot IV 100 mg. chlortetracycline 12 mg. hexestrol
Final wt., lb.	1137	1184	1163	1215
Market wt., lb.	1100	1133	1117	1158
Transit shrink, %	3.3	4.3	4.0	4.7
Cold carcass wt., lb.	668	690	685	715
Dressing percent	60.7	60.9	61.4	61.8
		Carcass Grades		
Low choice	3	2	1	1
High good	1	1	4	3
Average good	4	4	3	5
Low good	1	3	2	1
Top commercial	1	0	0	0
		Chemical Analysis of Twelfth Rib		
Moisture, % [a]	43.63	44.90	42.71	44.78
Crude protein, % [b]	12.75	13.86	12.38	13.65
Fat, % [c]	43.81	41.27	45.63	42.30

[a] LSMD, percent moisture—5% level, 1.95; 1% level, 2.62.
[b] LSMD, percent crude protein—5% level, 0.29; 1% level, 0.39.
[c] LSMD, percent fat—5% level, 2.92; 1% level, 3.92.

Effect on feed consumption and efficiency of feed conversion. Since the level of silage and Supplement A fed was the same for each of the four lots, the improvement in feed efficiency of these two constituents closely paralleled the improvement in growth. Hexestrol-fed cattle required approximately 18% less Supplement A and silage per unit of gain; antibiotic-fed cattle required 11% less; and when both treatments were administered, the cattle required 26% less of each the supplement and the silage per unit of gain.

There was a variation of from 5% to 13% in average amount of corn consumed per day among treatments.

During the first two weeks of the trial, the four lots consumed the same amount of corn. The appetite of the control lot which received neither hormone nor antibiotic lagged behind the appetites of the other three lots

starting in the third week. After 56 days on trial, neither of the lots receiving the antibiotic (Lots III and IV) were able to consume the amount of corn consumed by the animals in Lot II which were fed hexestrol.

The fastest gaining animals (Lot IV) which consumed almost 1 lb. less corn per day than the hexestrol-fed steers were markedly more efficient in utilization of feed. An apparent complementary effect in terms of efficiency of feed utilization when both hexestrol and chlortetracycline were fed was evidenced in Lot IV by a 22.2% improved efficiency of utilization of corn which is 1.6 times the sum of the improvement figures when the two were fed separately.

Effect on shrink-in-transit, dressing percent and carcass grade. Cattle which were fed no hormone or antibiotic had 0.7 to 1.4% less shrink-in-transit to market (65 miles distance). However, a lower dressing percent for this group of cattle narrowed the margin of performance among the four lots in terms of both shrink-in-transit and dressing percent. When both of these marketing losses are considered, steers fed the female hormone (hexestrol) suffered a loss of 1% more than the control steers, whereas those fed either the antibiotic (chlortetracycline) alone or in combination with the female hormone suffered total losses almost identical with the animals fed neither hormone nor antibiotic.

There was very little difference in carcass grades among the four lots of cattle.

Effect on chemical analysis of the meat from the twelfth rib. The twelfth rib from sternum to backbone from one side of each carcass was removed for chemical analysis. All of the meat and fat was removed, ground and chopped from each individual rib. A representative sample was taken from each carcass and analyzed for moisture, crude protein and fat. The meat from cattle which had been fed the female hormone alone (Lot II) or in combination with the antibiotic (Lot IV) contained significantly less fat and more protein and moisture than the meat from the steers fed antibiotic (Lot III, $P<0.01$) and than the meat from control steers fed no hormone approached significance at 5% level). Beeson *et al.* (1956) reported a similar carcass effect from the feeding of another female hormone-like material, diethylstilbestrol.

Summary

The feeding of 12 mg. of hexestrol per animal daily to two-year-old fattening steers in drylot resulted in a 24% increase in growth rate (2.03 vs. 2.50 lb. per day).

When hexestrol and chlortetracycline (Aureomycin) were fed in combination, the growth stimulatory effect was almost exactly equal to the sum of effects of the two when fed separately, indicating the growth stimulatory effects of these two substances are exerted independently and are additive.

Efficiency of feed conversion was improved when either the hormone or

antibiotic was fed alone, but the efficiency of conversion was increased when the two were fed together by an amount that is 1.6 times as great as the sum of the figures for improvement brought about by feeding either alone.

When both shrink-in-transit and dressing percent were calculated, cattle fed hexestrol suffered approximately 1% greater marketing and slaughter loss than cattle fed the antibiotic alone, than cattle fed both the antibiotic and the hormone, and than cattle fed neither antibiotic nor hormone.

There was no apparent variation in carcass grades among the four lots of cattle.

Chemical analysis of the meat from the twelfth rib showed the cattle fed the female hormone alone or in combination with the antibiotic contained less fat and more protein and water than meat from the animals fed antibiotic alone or else neither the hormone nor the antibiotic.

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STRAIN DIFFERENCES IN THE ESTROGENICITY OF ALFALFA [1]

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THE widespread occurrence of plant estrogens has been the subject of a recent review (Bradbury and White, 1954). Many workers have reported on the presence of estrogens in different species of plants, but there is little data concerning differences in estrogenicity of strains of the same plant species. The purpose of this work was to determine the estrogenic activity of 56 strains of alfalfa.

Experimental

The samples of alfalfa were second cuttings from individual clones harvested in the bud stage during July, 1955. The clones were grown in a clonal nursery of diverse genotypes on the Purdue Agronomy farm located in the vicinity of Lafayette, Indiana. Clones selected for assay included varieties of alfalfa such as Ranger, Grimm, Hardigan, Cossack, Buffalo, Viking, etc. The plant material was dried in a dehydrating oven at 170° F. for 48 hours. After drying, the samples were finely ground and 90 gm. of the dried, ground alfalfa were refluxed for one hour with 500 ml. of 95% ethyl alcohol. The material was filtered and rinsed with an additional 100 ml. of alcohol. The filtrates were poured over 90 gm. of laboratory ration and allowed to evaporate in drying ovens. The dried extracts were assayed for estrogenic activity by feeding them to mature, castrated female Rockland-Swiss mice at the rate of three grams per mouse daily for six days. On the seventh day the mice were sacrificed, their uteri were removed, split lengthwise and weighed. This procedure is a modification of the method described previously by Pieterse and Andrews (1956a). The method for the determination of the uterine response to diethylstilbestrol was that described by Stob (1956). Five mice were used for the assay of each sample of alfalfa; for the determination of uterine response to diethylstilbestrol, ten mice were used for each level of hormone. Control values are average uterine weights from mice fed only the laboratory ration.

Results and Discussion

All uterine weights of the mice fed the alfalfa extracts were heavier than those from the mice fed the control ration (table 1). This indicates some degree of estrogenic activity in all 56 strains of alfalfa. Differences in degree of estrogenic activity occurred in all the varieties of alfalfa indicating a lack of variety specificity in terms of estrogen content. In view of

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TABLE 1. UTERINE WEIGHT RESPONSE TO ALFALFA EXTRACTS

Alfalfa strain number	Mean body weight	Mean uterine weight	% body weight
	gm.	mg.	
Control ration	25.0	17.00	.068
262	22.4	18.60	.084
425	27.4	19.44	.071
253	27.2	19.72	.073
450	25.8	20.24	.079
4	24.8	21.12	.084
428	23.8	21.20	.089
246	23.0	21.45	.074
239	31.0	21.56	.070
459	23.6	21.80	.092
83	27.6	22.32	.081
12	27.6	22.32	.081
96	26.8	22.80	.087
424	26.4	23.20	.088
448	26.6	23.40	.088
317	27.4	23.78	.088
44	26.8	23.92	.090
419	23.4	24.04	.103
72	23.8	24.24	.104
339	25.6	25.08	.098
90	27.6	25.40	.093
401	26.8	25.44	.096
231	28.4	25.48	.086
76	23.5	25.50	.087
215	26.0	25.64	.100
334	28.0	26.00	.093
70	26.2	26.20	.100
284	28.0	26.80	.096
480	24.6	26.88	.110
23	25.4	27.08	.106
251	26.8	27.24	.102
315	27.0	27.28	.101
286	26.0	28.00	.108
224	28.0	28.28	.101
432	25.0	28.32	.113
31	26.4	28.76	.109
223	29.4	28.84	.095
249	27.6	29.48	.108
216	26.6	30.08	.115
38	26.0	30.44	.118
402	26.2	30.48	.116
442	26.2	30.52	.118
273	27.2	30.56	.112
473	24.4	31.00	.127
52	27.8	31.44	.111
82	27.0	32.36	.120
311	26.6	32.84	.126
261	25.2	33.72	.133
68	25.4	34.08	.134

(Continued on Next Page)

TABLE 1—*(Continued)*

Alfalfa strain number	Mean body weight	Mean uterine weight	% body weight
	gm.	mg.	
232	27.8	34.64	.124
80	27.6	35.80	.131
17	26.2	36.48	.139
399	27.0	36.76	.129
94	24.4	37.12	.153
277	27.6	41.20	.149
346	24.0	41.68	.173
138	28.2	99.96	.336

known strain differences of alfalfa in resistence to disease, growth habits and chemical composition, it is not surprising that differences in estrogenic activity exist. Strain differences in estrogenicity offer a possible explanation for the variation in uterine response of mice fed alfalfa (Cheng *et al.*, 1953; Pieterse and Andrews, 1956a) and alfalfa silage (Pieterse and Andrews, 1956b).

The increase in uterine weight resulting from feeding the alfalfa extracts ranged from 1.60 to 82.96 mg. The data in table 2 are provided to give some estimate of estrogenic activity in terms of a specific hormone. The validity of such a comparison is subject to several limitations. The estrogenic compound(s) present in alfalfa do not necessarily have the same degree of oral potency as diethylstilbestrol. The estrogenicity of the laboratory ration used for the establishment of the sensitivity of the mouse uterus to diethylstilbestrol may be different from the laboratory ration used to assay the alfalfa extracts. The control values (17.00 mg. vs. 20.92 mg.) indicate that this is so. For reasonably accurate quantitation of hormonal activity of alfalfa a more precise method must be used.

Both beneficial and detrimental effects have been attributed to estrogens

TABLE 2. UTERINE WEIGHT RESPONSE OF CASTRATED FEMALE ROCKLAND-SWISS MICE TO ORALLY ADMINISTERED DIETHYLSTILBESTROL

Diethystil-bestrol feed	Mean body weight	Mean uterine weight	% body weight
ug./gm.	gm.	mg.	
none	25.10	20.92	.084
.005	26.90	27.46	.102
.01	24.10	37.02	.155
.04	26.20	64.38	.250
.08	25.10	117.88	.471
.16	25.90	122.52	.474
.32	26.50	148.46	.554

in forage. They have been suggested as the factor(s) responsible for increased milk flow and increased growth. They have also been incriminated as a cause of sterility, dystocia and vaginal prolapse in ewes and mammary stimulation in wethers. The conflicting reports on the response of beef steers and heifers to diethylstilbestrol when the animals have access to pasture may be explained by variation in the estrogen content of forages.

Most of the investigations with plant estrogens have dealt with their relationship to effects on livestock. Of equal importance are the agronomic and biochemical aspects of these compounds. Research is needed, not only to characterize and identify the compounds which are estrogenic, but also to determine their role in the physiology of the plant.

Summary

The assay of 56 strains of several varieties of alfalfa indicates a wide variation in the estrogenic activity within a plant species.

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EFFECT OF PARA AMINO SALICYLIC ACID AND CHLORTETRACYCLINE ALONE AND IN COMBINATION ON DAIRY CALVES

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ACCELERATED growth frequently has been observed in dairy calves fed chlortetracycline (Aureomycin). The mode of action is not clear, but it seems likely that inhibition of infectious bacteria is involved (Lassiter, 1955). The effect of chlortetracycline on various organisms *in vitro* was increased tenfold (Sirsi and Kale, 1951) by the simultaneous use of para amino salicylic acid (PAS). The purpose of the present work was to determine whether this synergism applies also to calf nutrition, and if PAS alone might be a desirable feed additive.

Experimental

Twenty-five young calves were assigned to 5 dietary groups consisting of one Guernsey and four Jerseys which were comparable with respect to sex, body weight, and height at withers. The calves were removed from their dams the day they were born and were confined to individual pens for the duration of the 60-day experimental period.

The calves were fed colostrum through the first 4 days, whole milk through 21 days of age, and thereafter reconstituted skim milk was used. All milks were fed by nipple pail at the daily rate of 9% of body weight divided into two equal feedings. Chopped alafalfa hay and dry mixed concentrates were offered free choice. The concentrate feed contained 50 parts ground oats, 60 parts ground shelled corn, 40 parts wheat bran, 20 parts dried skim milk, 26 parts cottonseed meal (41% crude protein), 2 parts salt, and 2 parts bone meal.

Chlortetracycline [2] and PAS [3] were dispersed in the milk. The amounts allowed per hundred pounds body weight per head daily were as follows: A. None, Control; B. PAS, 90 mg.; C. Chlortetracycline, 45 mg.; D. Chlortetracycline, 45 mg., and PAS, 90 mg.; E. Chlortetracycline, 4.5 mg., and PAS, 90 mg.

All calves were observed for evidence of scours or other abnormalities and feed consumption was recorded daily. Body weights and heights at withers were determined initially and at subsequent weekly intervals.

The initial group-mean body weights were lacking in uniformity. These differences were not significant, however, as shown by an analysis of variance technique. The same procedure was used to analyse the experimental results (Snedecor, 1946).

[1] Florida Agricultural Experiment Station Journal Series No. 603.
[2] Supplied by Lederle Laboratories, Pearl River, New York.
[3] Purchased from Nutritional Biochemicals, Inc., Cleveland, Ohio.

Results

General health. No scouring was observed in any calf. The calves which received either PAS or chlortetracycline alone seemed especially alert. Their hair coats were glossier in appearance than those of the other calves.

Although the differences in appetite were slight, the use of PAS appeared to stimulate the consumption of hay. The calves in Group C, receiving only chlortetracycline as an additive, excelled in consumption of the mixed concentrates. The observations were insufficient to determine whether the slight differences were caused by the supplements or were due to chance. However, the calves receiving the combined supplements appeared not to differ from the controls in either appetite or general thriftiness.

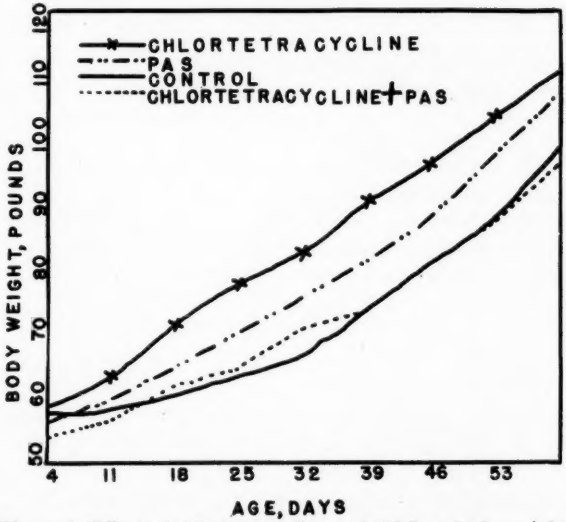

Figure 1. Effect of chlortetracycline and PAS on body weight.

Changes in body weight. Groups D and E, which received both supplements, gained at an almost equal rate; and hence the growth data of these groups were combined for presentation in figure 1.

The control group gained an average of 41 lb. (figure 1). Feeding of PAS as the only supplement to Group B resulted in an average gain of 51 lb., a difference which was significant at $P=0.01$. The mean gain for Group C, which was supplemented with chlortetracycline alone, was 53 lb. This gain likewise was significantly different at the 1% level from that of the control group. The small difference between the groups which received each supplement separately, however, was not significant.

Results observed in Groups D and E from the combined use of PAS

TABLE 1. RELATION OF CHLORTETRACYCLINE AND PAS TO GROWTH AND EFFICIENCY OF FEED CONVERSION

	Mean gain in				Feed intake per pound gain in body weight					
	Body weight	C [a]	Height at withers	C	Hay	Concentrate	Whole milk	Skim milk	Calculated [b] TDN	C
	lb.	%	cm.	%	lb.	lb.	lb.	lb.	lb.	%
Control	41	9	7.8	21	.4	.8	2.2	6.2	1.6	23
PAS	51	10	8.6	17	.4	.8	1.9	5.5	1.5	22
Chlortetracycline	53	11	10.7	9	.3	.9	1.7	6.1	1.6	2.4
PAS + chlortetracycline (45 mg. level)	43	10	7.4	21	.3	.9	2.0	6.2	1.6	3.1
PAS + chlortetracycline (4.5 mg. level)	42	27	7.8	2.4	.3	.9	1.9	6.2	1.6	4.6

[a] C=Coefficient of variation.
[b] Morrison, F. B., Feeds and Feeding. 21st ed. 1948.

with chlortetracycline were unexpected. It appeared that the 4.5 and the 45 mg. levels of chlortetracycline were ineffective in the presence of PAS. The average gains were 43 and 42 lb. respectively as compared with 41 lb. for the control group.

Effect on height at withers. The gain in height at withers was greatest in Group C, which averaged 10.7 cm. This was followed in order by Group B, 8.6; Group A, 7.8; Group E, 7.8; and Group D, 7.4 cm. Because individuals within groups varied considerably, none of these observations were statistically significant.

Effect on feed conversion. The average nutrient intake per pound of gain was lowest in Group B for which PAS was the only supplement (table 1). This difference, however, was not statistically significant.

Discussion

Under the conditions of this experiment, chlortetracycline and PAS were almost equal as growth factors. The two combinations studied were not compatible. However, further work with other combinations would seem desirable.

The fact that PAS alone stimulated growth lends support to the postulation that the growth-stimulating properties of antibiotics are due in part to their effect on bacteria (Lassiter, 1955). It seems likely that the antagonism between PAS and chlortetracycline occurred as the result of an adverse effect of the combinations on important symbiotic organisms.

Summary

Growth in young calves was stimulated by PAS and chlortetracycline when fed separately. Combinations of the two, however, resulted in growth which was not significantly different from that of comparable controls.

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THE INFLUENCE OF SODIUM BENTONITE *IN VITRO* AND IN THE RATION OF STEERS

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SODIUM bentonite, an "inert" clay, is sometimes used by commercial companies to improve the physical consistency of pelleted feeds. Laughland and Phillips (1954) found that sodium bentonite at a level of 3% of the diet limited the hepatic storage of vitamin A in rats when preformed vitamin A was fed. Similar results (Briggs and Spivey, 1954) indicated that diets containing 3% or more of sodium bentonite and 8720 I.U. of preformed vitamin A per kg. of ration made chicks vitamin A deficient. However, practical commercial diets that contained 5% of sodium bentonite produced no deleterious effect in birds in two other experiments by the same workers.

In view of the previous reports, the carotene-binding effect of sodium bentonite in steer rations was studied. Other measurements included growth rate, feed efficiency, and digestibility of certain fractions as well as hepatic vitamin A and carotene storage.

Experimental Procedure

It was originally planned to conduct an *in vitro* study followed by an *in vivo* experiment to complete this investigation. However, the results of the steer experiment prompted additional *in vitro* work. The various phases of the overall investigation will be discussed in the order they were conducted.

In vitro. Pure carotene (90% beta and 10% alpha) was dissolved in petroleum ether (4 mcg. per ml.). Increasing amounts of sodium bentonite were added to 20 ml. of this carotene solution and the mixture was shaken vigorously. Carotene was determined with a Coleman Universal spectrophotometer at 440 mμ.

The pH in the various segments of the GI tract of ruminants varies. Consequently, an *in vitro* experiment was conducted to study the effect of pH on the amount of carotene bound by sodium bentonite. The total daily feed and carotene requirement of a 660 lb. beef animal was estimated, and the amount of carotene that would occur in a 10 gm. sample of such feed (3 mg.) was placed in a series of tubes. Sodium bentonite was added at 0.1, 0.2, 0.3, 0.4, and 0.5 gm., or 1, 2, 3, 4, and 5% of the estimated 10 gm. feed sample. Each level of bentonite was subjected to a pH of

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[3] Scientific Paper No. 1599, Washington Agricultural Experiment Stations, Pullman; Project No. 1217.

7, 8, 9, and 10.6, produced by adding Na_2CO_3 and H_2SO_4. Carotene was determined on each sample spectrophotometrically.

In vivo. Twelve yearling Hereford steers were divided into four lots of three animals each and group-fed the all-pelleted rations shown in table 1. Six steers (lots 1 and 2) were fed the control ration without bentonite (ration 1) while the remaining six animals (lots 3 and 4) were fed a ration containing 3% sodium bentonite (ration 2) for 114 days.

TABLE 1. COMPOSITION OF ALL-PELLETED EXPERIMENTAL RATIONS

Constituents	Ration number	
	1	2
	%	%
Dehydrated alfalfa	25.0	25.0
Wheat	18.0	15.0
Oats	17.0	17.0
Linseed oil meal	14.0	14.0
Beet pulp	25.0	25.0
Salt	1.0	1.0
Sodium bentonite	—	3.0

After 36 days of the experiment, all steers were placed in digestion stalls (Erwin *et al.*, 1956a), and 24-hour fecal samples were collected. Digestion coefficients of dry matter and crude fiber were determined by the lignin ratio technique.

All steers were weighed at periodic intervals and feed consumption by pen was recorded. Liver samples were obtained from all steers at 0 and 100 days of the experiment (Erwin *et al.*, 1956b) and analyzed for vitamin A and carotene (Gallup and Hoefer, 1946).

The data of this study were subjected to analysis of variance (Snedecor, 1946).

Results

In Vitro. In the study in which increasing amounts of sodium bentonite were added to 20 ml. of the carotene solution, it was found that 0.75 gm. of bentonite completely bound 80 mcg. of carotene. The adsorption of carotene, and not its destruction, was demonstrated by the fact that the addition of acetone to the medium released the carotene quantitatively. Nearly a straight line relationship existed between the amount of bentonite present and the amount of carotene tied up.

Varying the pH of the medium had no effect on the amount of carotene bound. All the levels of bentonite completely bound all the carotene present. The pH range of 7 to 10.6 had no effect on its release.

In Vivo. The results of the *in vivo* experiment are summarized in table 2. No significant difference as the result of feeding 3% sodium bentonite to steers was found in either daily gain, feed efficiency, dry matter or crude fiber digestion, or in the hepatic storage of vitamin A and carotene. Because previous reports with rats (Laughland and Phillips, 1954) and chicks (Briggs and Spivey, 1954) and *in vitro* results at this station were not in agreement with the *in vivo* work with steers, an additional *in vitro* study was conducted.

TABLE 2. EFFECTS OF SODIUM BENTONITE FED TO FATTENING STEERS

	Control	Sodium Bentonite
Number of animals	6	6
Average daily feed consumption lb.	17.2	16.9
Average daily gain, lb.	2.18	2.36
Digestibility coefficients		
Dry matter	76.6	72.4
Crude fiber	44.6	45.5
Lb. feed/lb. gain	8.01	7.27
Hepatic retention (mcg./gm.)		
Vitamin A	+1.07	—1.72
Carotene	+1.58	+1.85

In Vitro Study 2. The diets of the steers in the previous study contained 25% of dehydrated alfalfa and 3% of sodium bentonite.

Three 2 gm. samples of dehydrated alfalfa were extracted with petroleum ether (B.P. 30–60) for 20 hours. Each extract was diluted to 100 ml. and divided into four 25 ml. aliquots (a, b, c, d). Sodium bentonite, 0.06 gm. (12% of the extracted alfalfa in the 25 ml. aliquot), was shaken with two 25 ml. aliquots (b, d) from each alfalfa sample (1, 2, and 3). All samples were centrifuged for 10 minutes at 2500 rpm. One ml. portions of samples 1a, 1b, 2a, 2b, 3a, and 3b were diluted with 5 ml. of petroleum ether and read against a petroleum ether blank at 475 mμ. The percentage of total pigment bound was calculated from the differences in optical density between the aliquots treated with and without the sodium bentonite. The carotene content of the aliquots 1c, 1d, 2c, 2d, 3c, and 3d was determined spectrophotometrically at 440 mμ. The percentage of carotene and total pigment bound by the added sodium bentonite is shown in table 3.

Discussion

In vitro sodium bentonite possessed a strong affinity for pure carotene. Also, under the conditions of this study, pH had no apparent effect on the binding of carotene by the clay. The second *in vitro* study showed that

sodium bentonite is not specific for carotene and that the clay apparently binds other non-carotenoid pigments as well. This finding helps explain the negative results found when bentonite was fed to steers that consumed a 25% dehydrated alfalfa ration. Apparently, there were sufficient amounts of other pigments in the steer rations to prevent the bentonite from having much effect on the carotene present. Briggs and Spivey (1954) reported corresponding results with chicks. That is, a purified diet containing vitamin A and bentonite produced vitamin A deficiency symptoms while a practical commercial diet with bentonite had no deleterious effect. Hunt *et al.* (1954) have found that sodium bentonite and other materials which

TABLE 3. THE INFLUENCE OF SODIUM BENTONITE ON TOTAL PIGMENTS AND CAROTENE FOUND IN ALFALFA

	Loss from Bentonite
	%
Carotene	8.9
Total pigments	11.0

possess adsorptive power likewise decrease the availability of riboflavin for the rat. This could indicate that organic substances other than pigments may compete with carotenoids for adsorption on sodium bentonite.

These results suggest that sodium bentonite at the 3% level has no effect on growth, digestibility, or feed efficiency. Sodium bentonite can be safely added to beef cattle rations that contain approximately the amount of carotene furnished by a 25% dehydrated alfalfa ration.

Summary

In vitro and *in vivo* studies with steers were conducted with sodium bentonite with the following results:

Sodium bentonite bound pure carotene *in vitro,* and altering the pH did not influence the release of carotene.

Three percent of dietary sodium bentonite did not significantly influence either the rate of gain, feed efficiency, digestibility of dry matter or crude fiber, or hepatic vitamin A and carotene retention in steers fed a diet containing 25% of dehydrated alfalfa.

Sodium bentonite bound other pigments in addition to carotene in dehydrated alfalfa. Probably sodium bentonite would have no deleterious effect on carotene use if the clay were incorporated into rations rich in pigments.

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SOME EFFECTS OF PELLETING A GROUND MIXED RATION ON FEED UTILIZATION BY FATTENING LAMBS [1, 2]

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WITH the increasing costs of production in agriculture the need for avoiding nutrient losses assumes a role of major importance. The feeding of roughages in pellet form provides a method of greatly reducing the sizeable losses of nutrients resulting from harvesting, storing and feeding. Labor costs are an important part of the cost of production. Pelleted feeds, particularly roughages, can be self-fed more efficiently and can be handled with less cost than unpelleted feeds because they are heavier per cubic foot and because they can be handled in bulk with machinery more easily than unpelleted feeds.

Esplin (1956) reviewed and grouped in tabular form the available comparisons of pelleted and unpelleted rations for lambs.

Nine experiment stations have reported (table 1) on the feeding of completely pelleted rations to 1187 lambs in 37 lots. A variety of roughages and concentrates were used in the various rations. Pellets were made using as much as 67% concentrates and 33% roughage. While other pellets consisted of as much as 70% roughage and 30% concentrates. Not all rations included molasses. A few of the rations included protein supplements.

Improved feedlot performance when pelleted feeds were fed seemed to be due largely to increased feed consumption. Four feedlot comparisons were reported in which the average daily consumption of pelleted feed was compared with the same amounts of unpelleted feeds. The gains were slightly heavier for the lambs fed the pelleted feeds with some saving in feed. Four feedlot comparisons showed more unpelleted feed consumed than pelleted feed. The gains were similar with some saving of pelleted feed. Seven feedlot comparisons were made with more pelleted feed consumed than unpelleted feed. The lambs fed the pelleted feed gained more with less feed needed to produce a pound of gain than the lambs fed the unpelleted feed. When the 15 comparisons were grouped, the average daily feed consumption was about the same. There was little difference in dressing percentage of the eight group comparisons in which slaughter data were available. In some of the experiments, lambs were marketed when they reached market grade while in other experiments the lambs

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were fed for a definite period of time. The carcass grades on 269 lambs fed pelleted feed were 2% prime, 79% choice, 18% good and 1% utility compared to the grades of 269 lambs fed unpelleted feed which were 68% choice, 30% good, 1.5% utility and 0.05% cull.

Five experiment stations have reported on apparent digestibility studies using 87 lambs in 11 groups fed pelleted rations and 105 lambs in 11 groups fed unpelleted rations. These digestion studies indicate that the apparent digestion coefficients for dry matter, crude protein, and nitrogen

TABLE 1. SUMMARY OF DATA FROM NINE EXPERIMENT STATIONS REPORTING ON FEEDING PELLETED FEEDS TO LAMBS

Form of feed	Number lambs	Initial weight	Final weight	Daily feed	Daily gain	Feed per pound gain
		lb.	lb.	lb.	lb.	lb.
Averages of lambs fed equal amounts of pelleted and unpelleted feed						
Pelleted	(79)	74	99	2.6	0.368	7.6
Unpelleted	(79)	74	96	2.8	0.313	9.1
Averages of lambs fed more unpelleted than pelleted feed						
Pelleted	(99)	74	102	3.0	0.320	9.6
Unpelleted	(98)	74	101	3.3	0.310	11.0
Averages of lambs fed more pelleted than unpelleted feed						
Pelleted	(180)	69	102	3.5	0.449	7.8
Unpelleted	(178)	69	97	3.2	0.347	9.9
Averages for all lambs fed pelleted and unpelleted feeds						
Pelleted	(358)	71	101	3.1	0.393	8.3
Unpelleted	(355)	71	98	3.1	0.328	10.0
Averages for all lambs fed only pelleted feeds						
Pelleted	(1187)	76	103	3.3	0.398	8.4

free-extract are similar for pelleted and unpelleted rations. The apparent coefficients tend to be higher for ether extract and lower for crude fiber when pelleted rations are fed than when the same rations are fed in the unpelleted form.

Bell *et al.* (1955) reported on the percent of nitrogen retained when lambs were fed pelleted rations compared to unpelleted rations. When rations of 55 and 65% dehydrated alfalfa and 45 and 35% cracked corn were fed to lambs in the pelleted form, 26.3 and 15.6% of the nitrogen fed was retained as compared to the same rations fed to lambs in the unpelleted form with only 2.2 and 0.2% of the nitrogen fed being retained.

In unpublished data from the Illinois Experiment Station (1955) the nitrogen retention was the same for the pelleted and unpelleted forms of two similar rations.

Blaxter and Graham (1956) investigated with lambs the digestibility of the nutrients and the utilization of energy in coarsely "chopped" and in

two types of cubed (pelleted) dried grass. Dried grass was ground to pass through a ¼ inch screen and cubed and designated "medium ground and cubed". Dried grass was ground twice and passed through a 1/16 inch screen and cubed and designated "finely ground and cubed". Digestibility and energy utilization were measured in respiration chambers. Two levels of feed intake were fed, 600 gm. and 1500 gm. per sheep per 24 hours. The digestibility coefficients when "chopped" dried grass was fed were higher for each nutrient studied than for either types of cubed dried grass except for ether extract. When 600 gm. of dried grass were fed, the digestibility of ether extract for the 600 gm. "finely ground and cubed" grass was higher than for the "chopped" grass. When 1500 gm. of dried grass were fed, the digestibility coefficients for ether extract with both cubed dried grasses were higher than with the "chopped" dried grass. Other coefficients compared were for dry matter, organic matter, crude fiber, nitrogen free extract, crude protein, cellulose, cellulosic pentosan, and non-cellulosic pentosan. The higher digestibility coefficients were found at the lower level of feeding with one exception. The digestibility coefficient for ether extract was highest with the high level of feeding "medium ground and cubed" dried grass. The standard error of the means was much higher for ether extract than for the other nutrients. There were no statistically significant differences in energy retention between the three forms of dried grass at either the high or the low level of feeding. Calculations of net energy per 100 kcal. of feed ingested showed the higher values to be at the lower levels of feeding. It was suggested that no large differences in the net energy would appear within the range of normal feeding, but slight extrapolation of the data indicated that the cubed grass would give higher net energy values than the non-cubed grass. Fecal losses of energy were higher and methane losses were lower when cubed grass was fed. The high fecal loss of energy when cubed dried grass was fed was due to the lower digestibility of structural components of the cell in the cubed grass than in the un-cubed grass. It was theorized that the physical factors which change the rate of passage of feed through the digestive tract, which change the rate and nature of the microbial fermentation and which cause variation in the mechanical work involved in prehending, masticating and cudding feed, are as important as the chemical composition of the feed in determining its nutritive value.

Jordan *et al.* (1954) and Thomas *et al.* (1954) compared pelleted concentrate feeds with unpelleted concentrate feeds fed to lambs. The gains and amounts of feed needed to produce the gains were similar, however, in each case they favored the pelleted feed.

Neale (1953, 1955) concluded that the self-feeding of 50 and 60% of poor quality alfalfa hay with 50 and 40% sorghum grain in the form of cubes or pellets to lambs had the definite advantage of saving feed when compared to hand-feeding good quality long alfalfa hay and whole sorghum grain.

Cate *et al.* (1955) compared 40% good quality roughage (alfalfa hay) with 40% poor quality roughage (timothy hay) fed to lambs both with 60% ground corn fed through most of the feeding period and both in the pelleted and unpelleted forms. They concluded that the pelleting of alfalfa hay with corn was of slight value, but the pelleting of timothy hay with corn greatly increased economy and rate of gain over the same ration fed as a ground mixture. Their data show that about the same amount of pelleted and unpelleted alfalfa and corn were eaten producing the same gain, with 9% less pelleted feed needed for each pound of gain than unpelleted feed. The lambs fed timothy and corn in the pellet form ate 0.42 lb. more feed per lamb per day than the lambs fed the unpelleted timothy and corn. These pellet fed lambs gained 0.45 lb. per lamb per day, or 0.16 lb. more than the lambs fed the unpelleted feeds. Pelleting of timothy hay with corn saved 2.7 lb. of feed in producing one pound of gain when compared to the lambs fed the same ration unpelleted.

Pelleting probably does not greatly change the nutritive value but improves palatability and forces the lambs to eat the grain and roughage in the proportions put into the pellet, thus controlling the concentrate and roughage ratio. Rations which include poor quality roughage when pelleted give larger, more efficient gains, and with higher grading carcasses than unpelleted rations with poor quality roughages.

Cox (1948) concluded after a long, thorough series of experiments designed to study concentrate and roughage ratios that an optimum physical balance actually exists in rations for fattening lambs. The concentrate and roughage ratio of the rations which gave the largest gains with the least amount of feed was 45:55. He further observed that weight gains made by lambs were not always positively correlated with either dry matter or total digestible nutrient intake, but appeared to follow a certain balance between these two factors determined by the crude fiber total digestible nutrient ratio.

Experimental Procedure

Five different experiments were conducted:

(1) Ten pairs of Columbia-type lambs were individually fed on an equal feed basis to determine if reported differences in feedlot performance by lambs fed pelleted feed compared with similar lambs fed the same ration in the unpelleted form were due to nutritive differences or to differences in amounts of feed eaten or to a combination of these factors.

(2) Two groups of ten Columbia-type lambs were individually self-fed to measure feed consumption and its effect on feedlot performance of lambs given free access to a pelleted ration compared with similar lambs permitted free access to the same ration in the unpelleted form.

(3) Two groups of 45 mixed Columbia and black-faced crossbred lambs were group fed to measure feedlot performance of lambs self-fed with an

opportunity for maximum feed consumption when the same ration was compared in the pelleted and unpelleted forms.

(4) Three digestion trials were conducted using a total of 36 lambs. Trials 1 and 2 were concerned only with digestion while Trial 3 included, in addition to digestion, nitrogen balance. Trial 3 was divided into two parts, part A and part B (the reversal).

(5) Two seven-day feeding periods with ten black-faced crossbred western lambs were used to determine if one of the physical forms was more palatable than the other form. These lambs had previously been fed both forms of the ration in digestion trial 3. A self-feeder 4 feet in length was divided giving two compartments. One compartment was filled with pelleted feed for the first period and with fresh unpelleted feed for the second period. The second compartment was filled with unpelleted feed for the first period and with fresh pelleted feed for the second period.

The feeds fed in all experiments were the same and were purchased from a commercial feed mill. Twenty tons of feed were mixed in a large feed mixer. Half of the mixture was pelleted and sacked while the remaining half was sacked without further processing. The pellets were one-fourth inch in diameter and about one-half inch in length. The ingredients used were 47.5% good quality alfalfa hay ground through a one-quarter inch screen, 47.5% finely ground corn, and 5% molasses. This ration was used in all tests in the pelleted and unpelleted forms. Water and salt with trace minerals were made available during the feeding periods.

Results

The gains of the lambs fed equal feed (table 2) were similar for both groups of lambs. The lambs fed pelleted feed required 0.4 lb. less feed to produce a pound of gain than the lambs fed the unpelleted feed.

Both groups of lambs individually self-fed (table 2) consumed the same amount of feed. The gains were similar and similar amounts of feed were needed to produce a pound of gain.

In both tests, there were no significant differences as measured by the "t" test between the lambs fed pelleted and the lambs fed the unpelleted feed. The comparisons made were initial weight, final weight, total gain, total feed, feed per pound of gain, dressing percent, chilled carcass weight, and carcass grade.

The lambs group self-fed (table 2) the pelleted feed ate one-half pound more feed per lamb per day than the lambs group self-fed the unpelleted feed. The lambs fed the pelleted feed gained 0.515 lb. per lamb per day while the lambs fed the unpelleted feed gained 0.445 lb. per lamb per day. The amount of feed needed to produce a pound of gain was about the same for both forms of the ration. The chi square for feed consumption and feed per pound of gain and "t" values for gain were significant at the 0.01 level of probability. Differences as measured by "t" values in

initial weight, final weight, dressing percentage, and chilled carcass weight were not significant.

One can observe from the three feeding tests that the gains and amounts of feed necesary to produce the gain were similar when equal amounts of feed were consumed. Lambs that were group self-fed consumed larger amounts of the pelleted feed than similar lambs group self-fed unpelleted feed with increased gains and with only a small saving in feed needed to produce a pound of gain. In each test the dressing percentage and carcass grades favored the pellet fed lambs.

TABLE 2. SUMMARY OF FEEDING TESTS

	Equal	Hand-fed	Individually self-fed		Group	Self-fed
	pelleted	Un-pelleted	pelleted	Un-pelleted	pelleted	Un-pelleted
Number of lambs	10	10	10	10	44	45
Av. initial weight, lb.	71.9	71.7	74.7	74.3	70.4	71.6
Av. final weight, lb.	97.7	95.8	101.8	100.9	103.9	102.0
Number first shipment	—	—	—	—	30	23
Weight first shipment, lb.	—	—	—	—	100.5	102.6
Number not shipped	10	10	10	10	14	22
Weight not shipped, lb.	—	—	—	—	92.9	87.4*
Weight last shipment, lb.	97.7	95.8	101.8	100.9	111.2	101.3**
Average daily gain, lb.	0.369	0.344	0.387	0.380	0.515	0.445**
Feed per pound of grain, lb.	8.3	8.7	9.3	9.2	7.5	7.6
Total feed, lb.	203.9	202.2	243.3	245.0	323.4	278.9**
Average daily feed, lb.	2.9	2.9	3.5	3.5	3.9	3.3
Dressing percentage	52.8	52.1	54.5	52.7	51.6	51.4
Average U.S. Carcass Grade	Low choice	High good	Low choice	Low choice	Low choice	High good **

* Significant difference at the 0.05 level of probability using "t" test or chi square between group fed pelleted and unpelleted rations.

** Significant difference at the 0.01 level of probability using "t" test or chi square between group fed pelleted and unpelleted rations.

The chemical composition (table 3) of both pelleted and unpelleted feed fed in the digestion trials were similar. The unpelleted feed fed in Trial 3A was somewhat higher in ash and nitrogen than the feeds fed in the other trials.

There were no significant differences in apparent digestibility (table 4) between pelleted and unpelleted feed for dry matter, ether extract, crude fiber, and nitrogen free-extract. The apparent digestibility of nitrogen had significantly higher "F" value for the unpelleted feed at the 0.05 level of probability than the pelleted fed. That difference was possibly due to an error in taking the sample from the feed fed in Trial 3A.

The nitrogen balance (table 4) was not statistically different between the two physical forms. The pellet-fed lambs retained 25.2% while the

lambs fed the unpelleted feed retained 26.3% of the nitrogen consumed.

Ten lambs ate 164.5 lb. of pelleted feed and only 50 lb. of unpelleted feed the first week during which time they had free-choice of either feed. During the second week lambs ate 213 lb. of pelleted feed and 42 lb. of unpelleted feed. The total amount of feed eaten for the two-week period

TABLE 3. CHEMICAL COMPOSITION OF FEEDS FED IN DIGESTION TRIALS (PERCENT)

Trial	Dry matter	Ether extract	Ash	Crude fiber	Nitrogen	Nitrogen free-extract
			Pelleted feed			
1 and 2	90.0	2.1	5.0	13.7	1.9	57.2
3A	90.0	2.3	5.0	14.1	2.0	56.5
3B	91.6	1.9	5.0	15.0	2.0	57.5
Average	90.5	2.1	5.0	14.3	1.9	57.1
			Unpelleted feed			
1 and 2	90.7	2.1	4.7	14.4	2.0	57.1
3A	89.6	2.1	7.0	14.7	2.3	51.4
3B	91.6	2.0	4.6	14.6	2.0	58.1
Average	90.6	2.1	5.8	14.5	2.1	55.5

was 377.5 lb. of pelleted feed and 92 lb. of unpelleted feed or four pounds of pelleted feed for each pound of unpelleted feed.

The contents of the rumen, reticulum, omasum, and obomasum were examined visually from six lambs fed pelleted feed and from six lambs fed unpelleted feed, both groups fed these feeds for three days prior to slaughter. From visual examination, there were no differences in the contents of the various parts of the stomachs between the two groups of lambs.

A bushel of each of the two physical forms of the experimental ration was weighed. The bushel of pelleted feed weighed 44 lb. while the bushel of unpelleted feed weighed 30 lb. or a difference of 45%. Jordan *et al.* (1954) reported that a bushel of pelleted feed consisting of 60% corn and 40% ground alfalfa hay weighed 38 lb.

Summary

Three feedlot tests were conducted with lambs using individual and group feeding to compare the relative value of a ration consisting of 47.5% ground corn, 47.5% ground alfalfa hay, and 5% molasses fed in the pelleted and unpelleted forms. Three digestion trials and a nitrogen balance trial were conducted comparing the pelleted and unpelleted feed when fed to lambs. A palatability test was conducted using the pelleted

TABLE 4. SUMMARY OF APPARENT DIGESTION COEFFICIENTS AND NITROGEN RETAINED (PERCENT)

	Dry matter	Ether extract	Crude fiber	Nitrogen	Nitrogen free extract	Nitrogen balance
			Pelleted feed			
			Trial 1 (4 lambs)			
Range	69–71	58–69	26–31	64–70	79–81	
Average	70.1	65.0	27.3	66.5	80.2	
			Trial 2 (4 lambs)			
Range	68–69	59–67	28–33	59–65	73–78	
Average	68.6	61.9	30.6	61.2	76.5	
			Trial 3A (5 lambs)			
Range	69–73	68–73	35–37	62–70	78–83	23–34
Average	71.2	69.7	35.8	66.0	80.3	28.6
			Trial 3B (5 lambs)			
Range	66–71	58–68	28–37	56–69	70–81	19–26
Average	68.3	61.6	33.0	62.4	76.6	21.7
			All Pelleted Feed Trials			
Range	66–73	58–73	26–37	56–70	70–83	19–34
Average	69.5	64.5	31.7	64.0	78.4	25.2
			Unpelleted feed			
			Trial 1 (4 lambs)			
Range	69–73	65–68	32–39	63–70	78–80	
Average	70.6	66.5	35.8	65.8	79.7	
			Trial 2 (4 lambs)			
Range	66–74	63–67	22–47	62–73	77–84	
Average	70.0	65.1	34.7	65.8	79.0	
			Trial 3A (5 lambs)			
Range	66–70	65–70	29–34	66–74	77–80	22–32
Average	67.8	68.0	32.3	69.7	78.1	27.4
			Trial 3B (5 lambs)			
Range	70–74	60–65	36–42	64–71	80–83	21–28
Average	71.9	62.9	37.7	66.2	81.3	25.1
			All Unpelleted Feed Trials			
Range	66–74	60–70	22–47	62–74	77–84	21–32
Average	70.0	65.6	35.1	66.9	79.5	26.3

and unpelleted feeds. Rumen contents from lambs fed pelleted feed and from lambs fed unpelleted feed were examined. The weights of a bushel of pelleted and of unpelleted feed were determined.

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A METHOD OF FEEDING SUPPLEMENTS TO INDIVIDUAL CATTLE ON WINTER RANGE [1]

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MORE than a million cattle in the Intermountain area receive a large portion of their forage supply from the open range. Methods of management are varied; some graze the desert or semi-desert in winter, the foothills in spring and fall, and the higher mountains during the summer, while others graze the semi-desert throughout the year. These ranges have a diversity of soil, climate, topography, and vegetation and frequently are deficient in one or more essential nutrients.

Various ways have been devised to feed supplements experimentally on the range. Usually groups of livestock are put into a series of pastures with each group receiving a different treatment. However, it is difficult to find pastures that are uniform enough in plant composition and topography so the results are not influenced by pasture variability. This is true even though the animals are rotated among pastures.

On western winter ranges 25 to 80 acres of grazing area is required per cow. Therefore, the cost of fencing pastures for a sufficient number of cattle to effectively measure variability is high. This has limited the progress of cattle and sheep research.

Harris *et al.* (1952) designed and utilized portable feeding pens, corrals and weighing crates for feeding and weighing range sheep individually. Through the use of this equipment it has been possible to do research in many areas and carry on experiments which take into account the variability of vegetation and climatic conditions.

The same general plan has been used to design feeding and weighing equipment to carry on similar work with range cattle (figures 1, 2, and 3).

Equipment

Corrals and chutes were constructed of lodgepole pines. Fence posts were 8 ft. high and gate posts 14 ft. high. Posts were set 8 ft. apart. Fence poles were 3 to 5 in. in diameter and 18 ft. long. Holes were made in all posts and poles in such a manner that the whole unit could be dismantled and moved to a new location when necessary. All fences were 5.5 ft. high with five fence poles used on the holding and cutting corrals and six on the chutes and crowding pen. It is possible to enlarge these corrals and chutes both in length and width in increments of 16 ft., should it be desirable to

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hold more animals. The holding corral measured 58 by 48 ft. It was possible to work 65 head of cattle in this area. The cutting corral measured 32 by 32 ft., and would hold 65 head of cattle under somewhat crowded conditions.

The crowding pen was 16 by 20 ft., and could easily hold 10 to 14 cows. Three chutes branched from the crowding pen, one to the loading chute,

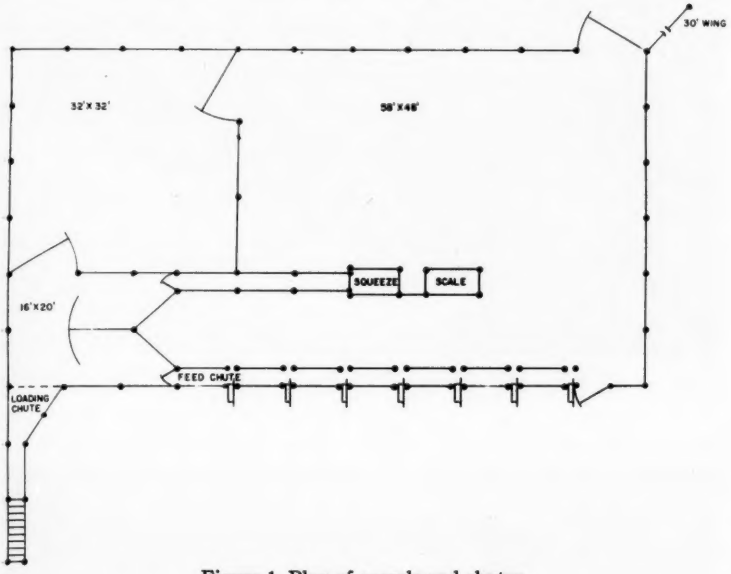

Figure 1. Plan of corrals and chutes.

one to the squeeze chute and scale, and the other to the feeding chute (figure 1). The loading chute was partitioned by removable poles when not in use. A two-way gate made it possible to use either of the other chutes at one time.

The chutes to the squeeze chute and scale were 26 in. wide on the inside, which proved to be adequate. The chute leading to the squeeze chute and scale was 24 ft. long. The feeding chute was 56 ft. long and was divided into individual feeding pens at 8-ft. intervals (figure 3). Doors holding the feed boxes were placed in the chute at 8-ft. intervals (figure 2). This allowed seven cows to be fed at one time. The doors fit between two posts on each side of the chute, which held them in a firm position. The doors were constructed of 2 x 6 x 10 in. planks. The doors were solid to prevent excreta from going through the door into feed box of the stall behind. The doors were 4 ft. wide and 4.5 ft. high. The doors were moved into the chutes on 2-in. pipes, 8 ft. long bolted across the top of the chute. The doors were connected to the pipe by 2 x ⅜ in. iron bands bolted to the

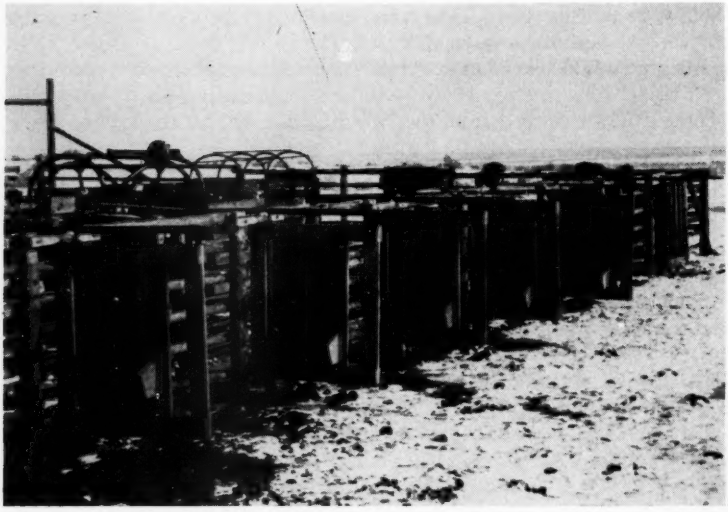

Figure 2. Gates and feed troughs were hung on pipes to partition the chutes (figure 3) into small feeding pens.

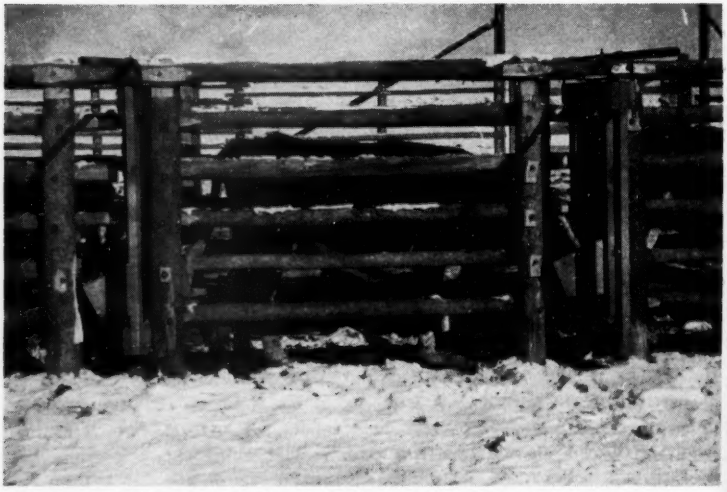

Figure 3. Side view of chute showing cattle eating their supplements.

gate and going over the pipe. Lubricant on the pipe facilitated moving the gates in and out of the chutes with ease. A short length of chain with a snap in one end was attached to the fence near each door and snapped into a ring attached to the door to prevent cows from pushing the doors open while feeding.

Feed boxes were built of one-inch lumber, 24 in. long, 8 in. wide and 6 in. deep. They were hung on the doors with small nails to a 2 x 6 board running horizontally along the bottom of the door. Boxes attached solidly to the doors were broken by excited cows, while those attached in this way were only knocked down and could be replaced without damage.

All gates were 5 ft. high. The entrance gates to the holding and cutting corrals and crowding pen were 10 ft. long, while the gate to the chutes in the crowding pen was 8 ft. long, and the one at the end of the feeding chutes was 5 ft. long. This gate enabled the feeder to turn cows either back into the holding corral or onto the range. Gates were constructed using 2 x 6 in. lumber and 5/16 in. bolts. The spacing between bars was 7 in. on the two bottom openings, and 8 in. on the remainder. Hinges were constructed from ¼ x 2 in. iron and ⅞ in. round rod. These hinges were adjustable so the top eye bolt could be drawn into the gate post to lift the end of the gate to desired distance from the ground. Hinges constructed in this manner permit gates to be opened to the fence in either direction, so as not to interefere with or injure livestock.

All gates in the holding corral, cutting corral, and crowding pen were constructed to swing in either direction to facilitate moving cattle into or out of the corrals. A wing extended 30 ft. from the outside gate of the holding corral to assist in moving cattle into the corral.

A squeeze chute was used to control animals when making individual observations. It was mounted on a trailer to facilitate moving, but could be loaded or unloaded by means of a winch which was attached to the trailer.

Method of Feeding Cattle

The cattle used in this study were selected at random from two average range herds. These animals normally graze both summer and winter range, and had been handled little prior to being placed on experiment. They were identified by means of bronze number tags attached to small chains around their necks.

Cows were assigned to treatment at random. Each lot of a particular supplement was given the same number as the cow to which the treatment had been assigned. Feedings were made at one-, two-, and three-day intervals. Cows were allowed to graze at distances as great as six miles in any direction from the feed corrals. No effort was made to control them other than the distance they drifted. When fed, the cows were allowed to go into the feeding chute at random. Feed cans were lined up in numerical

order just outside the chutes. The number on the cow was checked, and the corresponding can of feed bearing this number was fed.

Results and Discussion

The equipment was found to be satisfactory for handling 60 to 65 cattle. Corrals built of heavy materials were required to handle cattle of the wild nature encountered. Many of the cattle used in this study had not been fed pellets previously and it was necessary to hold them in the corral several hours at first before they would consume them.

Daily feeding was unsuccessful, as it took considerable time to gather and feed the cattle. This left insufficient time for the cattle to graze. It was found that cattle in this area would come to water rather regularly every other day. When feeding and watering were correlated, little time was needed to put the cattle in the chutes for feeding. Cows did not establish a habit of coming to eat when fed every third day, as they did when fed every other day.

Water was found to be critical. It was found preferable to have the water near or in the corrals. When cattle came for a drink, they could be put in and fed their supplements. A shortage of water, or dirty water caused cattle to leave the area in a short time.

Ten days time was required to establish a feeding pattern, and after this even wild cows could be fed in the chutes without difficulty. Two hours maximum time was required to feed 60 head of cattle with the equipment designed and used in this study.

Since this research was completed, the Nevada investigators, Bohman *et al.* (1955), have adapted this individual feeding design to the portable arrangement. They have also found that cattle can be successfully fed individually on the range.

Summary

Equipment was designed to feed supplements to cattle grazing on the winter range by the use of temporary corrals and feeding chutes. Cattle were fed more successfully every other day than daily or every third day. A feeding period of approximately 10 days was required before wild cattle could be fed in feeding chutes without difficulty. Once a feeding pattern had been established, it was possible to feed 60 head of cattle in less than two hours. With this technique it is possible to design range experiments to take into account the effects of treatment without bias due to pastures and climatic variables encountered in group feeding.

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EFFECT OF GESTATION DIETS AND CREEP FEEDING ON LIVABILITY AND WEIGHT GAINS OF SUCKLING PIGS

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In their excellent review on the effects of nutrition on reproduction, Friedman and Turner (1939) point out that although claims of essentiality have been made for most dietary ingredients, little evidence exists that requirements for reproduction (excluding lactation) differ quantitatively or qualitatively from the requirements for growth and maintenance. Reid (1949), in a comprehensive review on the relationship of nutrition to fertility in animals comes to a similar conclusion.

Data presented by Guilbert and Goss (1932) and Pearson *et al.* (1937) indicate that both quantity and quality of protein may be important for normal reproductive function. Meites (1953) observes that most of the earlier studies concerning effect of protein on reproduction were complicated by vitamin deficiencies and inanition and that the problem deserves further study.

The Biennial Reports from Oklahoma Agricultural Experiment Station for 1934–36, 1936–38 and 1938–40 give results of a series of experiments on rats and swine which show small but consistent advantages for higher levels of protein during gestation in terms of survival of the young to usual weaning ages.

Except in the Oklahoma study these investigators have been primarily interested in reproductive activities preceding and including birth such as sexual maturity, estrus, ovulation, conception rate, and birth data. While all of these phenomena exert a marked effect on reproductive performance, the experiments herein reported are particularly concerned with dietary factors which may increase average production per litter either in number of pigs surviving or weight gains at a given age. An examination of farrowing and weaning results at Beltsville and at a number of experiment stations throughout the North Central States suggested that the diets in general use were quite adequate in terms of number of live pigs born. However, almost none of the diets were effective in improving livability (survival at 8 weeks) above the generally accepted "norm" of 70–75% (about 6 to 7.5 pigs per litter). One notable exception was the increased survival rate attributed to an increased allowance of riboflavin during gestation as reported by Miller *et al.* (1953).

Workers at Illinois, Missouri and Wisconsin had also reported marked

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increases in survival rate from supplementation of gestation diets with B-vitamin concentrates.

A number of investigators, Carpenter (1951), Carpenter and Larson (1953), Vestal *et al.* (1952), Dyer (1952), Nordfeldt (1955), Catron (1953), Beeson *et al.* (1953), Davey and Stevenson (1953) and Davey *et al.* (1955) have studied antibiotic-vitamin B_{12} concentrates as supplements to sow diets. No adverse effects have been reported but observed benefits have been few and results inconclusive.

Creep feeding of suckling pigs was reported as beneficial by Krider *et al.* (1950), Aubel (1950) and Terrill *et al.* (1952). The more restricted diets for the sows resulted in lower weights of control pigs and a greater advantage in favor of creep feeding.

The reports of the Committee on Animal Nutrition of the National Research Council have reviewed the quantitative data available on nutrient requirements for swine. A careful examination of this publication Beeson *et al.* (1953) revealed a number of calculated values and interpolations for which substantiating data were not available. The tables on nutrient requirements for market stock from weaning to usual slaughter weights were generally based on adequate research data and recent developments in baby pig nutrition have provided a sound basis for the requirement figures for younger pigs. In the field of nutrient requirements for optimum reproductive performance, however, there is relatively little accurate quantitative evidence on needs for specific dietary factors. Most of this research has been of a qualitative nature (as with crude sources of B-vitamins) and attempts to evaluate particular effects of single deficiencies have frequently been obscured by inanition and deficiencies of other nutrients. Consequently, nearly all of the requirement figures for breeding stock have been extended from data obtained on growing-fattening pigs.

A series of preliminary or pilot-type experiments preceded the trials covered in this report. The first experiment (1949–50) confirmed the accuracy of a suggested minimum daily allowance of carotene for pregnant sows at 4 mg. per 100 lb. of body weight and indicated 25 to 40 mg. per sow daily as adequate for lactation. In this same test, additions of riboflavin, pantothenic acid and fish solubles to the regular Beltsville sow diet did not improve survival rate or growth rate of baby pigs. In the second experiment (1951), the addition of 5 to 15% of dehydrated alfalfa meal to a basal gestation diet of corn, soybean oil meal, vitamins and minerals was without apparent effect on reproductive performance of first-litter gilts but with their second litters resulted in weaning 86.8% of all pigs born compared to 52.2% survival of pigs from sows receiving the basal diet without alfalfa meal. In this instance the small number of litters involved prevented a reliable estimate of significance.

The main trials described in this report were designed to study the effects of protein level and of antibiotic-vitamin B_{12} supplementation during gestation and lactation on reproductive performance. This performance was

measured in terms of health and condition of the sows, number of pigs born, incidence of stillbirths, and number and condition of pigs weaned at 56 days of age. Various creep feeding practices were also investigated as methods for improving productive efficiency through increasing pig weights at a given age.

Experimental Procedure

The first experiment (farrowing seasons of 1952 and 1953) was set up in a 2^4 factorial design. The treatment variables were: (1) protein levels of 15 or 20% during gestation, (2) supplementation with chlortetracycline-vitamin B_{12} during gestation, (3) protein levels of 15 or 20% during lactation, and (4) use of a pelleted pig starter containing chlortetracycline B_{12} concentrate to supplement sows milk.

In the second experiment (1954 and 1955 farrowing) the same design was used but three treatment variables were changed. First the high level of protein during gestation was reduced from 20% to 17.5%. Next since differences in protein content of lactation diets did not apparently affect survival rate or 56-day weights of baby pigs, the lactation variable was replaced by a comparison between the basal growth diet of the gilts (from weaning to gestation) and the same diet supplemented with chlortetracycline-B_{12} concentrate. Similarly, since creep feeding had increased weaning weights in the first trial, the second experiment compared the results of creep feeding the starter diet containing chlortetracycline-B_{12} concentrate and the same diet without the supplement.

The composition of the experimental diets is presented in table 1. The sow diets are patterned after the gestation and lactation diets used in the main breeding herd at Beltsville with proportions of corn and protein concentrates adjusted to provide the prescribed protein level while oats, alfalfa meal, and mineral content were held relatively constant.

Gilt pigs were saved from spring litters each year to produce pigs during the following year. These gilts were self-fed the standard record of performance diet on pasture until they reached about 200 to 225 lb. average weight. They were then shifted to limited feeding on pasture until the start of the breeding season when they were moved to concrete floored pens. The gilts were assigned to experimental treatments as they were bred. The assignment was completely randomized except for provision to prevent litter mates receiving the same treatment. The experimental lots were hand fed at approximately 1.8 and 1.3% of their body weight during their first and second gestation periods, respectively, and were discarded after weaning their second litters. The sows (or gilts) were washed and placed in conventional farrowing pens on the 109th day of gestation with feed reduced to 1% of body weight. Feed was withheld for 24 hours after parturition followed by an initial feeding of about 2¼ lb. of diet with gradual daily increases until the sows reached full feed about the 10th

day, at which time they were placed on self-feeders. Standard procedures included provision of guard rails, heated brooder areas, cleaning and sanitation.

TABLE 1. COMPOSITION OF EXPERIMENTAL DIETS

Gestation Diets

Ingredients	1952–53–54–55		1952–53		1954–55	
	1	2	3[a]	4[a]	3[b]	4[b]
	%	%	%	%	%	%
Ground yellow corn	57.95	57.95	49.11	49.11	53.53	53.53
Ground oats	15.80	15.80	13.39	13.39	14.60	14.60
Dehydr. alf. meal	15.00	15.00	15.00	15.00	15.00	15.00
Soybean oil meal	2.73	2.73	5.80	5.80	4.26	4.26
Linseed oil meal	1.82	1.82	3.86	3.86	2.84	2.84
Tankage	2.72	2.72	5.79	5.79	4.26	4.26
Fish meal	2.73	2.73	5.80	5.80	4.26	4.26
Reg. min. mix [a]	1.00	1.00	1.00	1.00	1.00	1.00
Glauber's salts	0.25	0.25	0.25	0.25	0.25	0.25
Vit. D (I.U./lb.)	50	50	50	50	50	50
Chlortetracycline—B_{12}[b]	—	0.3	—	0.3	—	0.3
Crude protein	15	15	20	20	17.5	17.5

Lactation diets

Ingredients	1952–53		1954–55	Starter diet (Suckling pig)	
	A	B	AB		
	%	%	%		%
Ground yellow corn	54.75	35.20	44.98	Ground yellow corn	30.00
Ground oats	15.00	15.00	15.00	Oat groats (rolled)	30.00
Std. wheat mids	12.25	22.70	17.48	Dehydr. alf. meal	4.00
Dehydr. alf. meal	5.00	5.00	5.00	Soybean oil meal	7.50
Soybean oil meal	5.25	9.80	7.52	Fish meal	8.00
Tankage	2.62	4.90	3.76	Dried skimmilk	10.00
Fish meal	2.63	4.90	3.76	Dried brewer's yeast	3.75
Reg. min. mix [a]	2.25	2.25	2.25	Molasses, cane	5.50
Glauber's salts	0.25	0.25	0.25	Spec. min. mix [c]	0.25
Vit. D (I.U./lb.)	50	50	50	Salt, iodized	0.50
				Chlortetracycline–B_{12}[b]	0.50
				Vit. D (I.U./lb. diet)	100
Crude protein	15	20	17.5		22.5

[a] Ground limestone, 32.0%; steamed bonemeal, 31.90%; iodized salt, 30.6%; magnesium sulfate, 2.5%; ferrous sulfate, 2.1%; cupric sulfate 0.2%; manganous sulfate, 0.5%; cobaltous sulfate, 0.1%; and zinc oxide, 0.1%.

[b] Supplied a minimum of 5.4 mg. chlortetracycline and 5.4 mcg. vitamin B_{12} per pound of feed in the gestation and lactation diets and 9.0 mg. chloreteracycline and 9.0 mcg. vitamin B_{12} per pound of starter diet.

[c] Ground limestone, 85.6%; ferrous sulfate, 12.0%; cupric sulfate, 1.2% and manganous sulfate, 1.2%.

Results and Discussion

The results of this series of experiments emphasize the rather wide range in individual performance which is commonly found in farrowing and weaning records of swine. This inherent variability of the experi-

TABLE 2. EFFECT OF GESTATION DIETS ON LIVABILITY OF BABY PIGS

	Diet 1	Diet 2	Diet 3	Diet 4
	15% protein	15% protein + antibiotic	20% protein	20% protein + antibiotic
1952–53 (Total of 4 farrowings)				
No. of litters	45	43	47	44
Av. No. pigs farrowed per litter	10.3	10.3	10.2	9.5
Av. wt. at birth (lb.)	2.30	2.54	2.54	2.52
Percent weaned 56 days	73.7	82.8	82.7	84.7
	15% protein	15% protein + antibiotic	17.5% protein	17.5% protein + antibiotic
1954–55 (Total of 3 farrowings)				
No. of litters	36	32	35	31
Av. No. pigs farrowed per litter	10.8	9.5	10.2	9.9
Av. wt. at birth (lb.)	2.45	2.50	2.48	2.53
Percent weaned 56 days	73.9	72.4	79.3	83.1

mental material almost invariably precludes the detection of small treatment differences except at the cost of excessive replication.

Farrowing and weaning data which appeared to be affected by dietary treatments are summarized in tables 2 and 3. The compilation and statistical analysis of data on such performance criteria as health and condition of sows, average number of pigs born, and birth weight of pigs showed no apparent dietary effect of the prescribed experimental treatments.

TABLE 3. EFFECT ON 56-DAY WEIGHTS OF "CREEP" FEEDING PELLETED STARTER DIETS TO SUCKLING PIGS

	Weight at 56 days of age, lb.			
	1952		1953	
	Spring	Fall	Spring	Fall
With starter diet (containing antibiotic-B_{12})	33.4**	41.5**	37.8**	34.6
Without starter diet (containing antibiotic-B_{12})	24.8	27.5	28.7	32.8
	1954		1955	
	Spring	Fall[a]	Spring	Fall
Starter diet (without antibiotic-B_{12})	35.2	[a]	32.1	34.5
Starter diet (containing antibiotic-B)	39.1**	[a]	34.4	34.0

[a] See footnote, page 7 concerning high incidence of "mummefied" pigs.
** $P<.01$.

Moreover, the addition of antibiotic-B_{12} concentrate to the growth diet of gilts did not affect subsequent reproductive ability, and increased protein content during lactation was also ineffective.

The use of relatively high levels (20 or 17.5% vs. 15%) of crude protein in the gestation diets provided the largest and most consistent improvement in reproductive performance as measured by viability or survival rate of baby pigs (Table 2). The seven [2] farrowing seasons included in this study provided seven group comparisons between sows receiving diets which contained 15% of crude protein and sows receiving diets which contained either 20 or 17.5% crude protein. Measured in terms of percentage of all pigs born which survived to 56 days of age these seven comparisons, showed six in favor of the higher protein gestation diets, and one resulted

TABLE 4. EFFECT OF DIETARY TREATMENTS ON BODY WEIGHT OF SOWS DURING GESTATION AND LACTATION (lb.)

	15% Protein		20% Protein		15% Protein		17.5% Protein	
	Basal	Antibiotic vitamin B_{12}	Basal	Antibiotic vitamin B_{12}	Basal	Antibiotic vitamin B_{12}	Basal	Antibiotic vitamin B_{12}
Start of breeding season	260	269	257	247	234	243	241	238
End of first gestation	405	415	397	395	346	358	361	352
End of first lactation (rebred)	343	350	338	336	307	331	311	300
End of second gestation	468	472	457	454	408	442	419	389
End of second lactation	418	416	416	415	337	384	381	349
No. of sows [a]	19	19	22	21	13	10	12	9

[a] Includes only sows which produced two consecutive litters.

in a virtual tie. This difference (approximately 7% or .7 pig in a 10-pig litter) was significant ($P<.02$). In the one comparison where the higher protein level failed to show a definite advantage over the lower protein level the failure was due to unusually good performance by the control group rather than poor performance by sows on the higher level.

It seems worthy of mention that this investigation was not designed to differentiate between the effects of protein per se and the level of vitamins provided by the increased proportion of protein concentrates in the higher protein diets. The similarity between survival rates from the higher protein diets and the higher riboflavin diets reported by Miller *et al.* (1953) suggested that the beneficial effect might indeed have been due to vitamin concentration rather than protein content.

The results obtained from chlortetracycline-vitamin B_{12} supplementation have been somewhat less consistent than those attributed to protein level. The first trials (1952) seemed to indicate an increased survival rate of pigs from sows which had received the supplemented gestation diets. This

[2] In the fall of 1954 there was a very high incidence of fetal cadavers or "mummefied" pigs born in all treatment groups. Since there was no evidence of dietary influence and the data were distorted, it was decided to omit fall 1954 results from this report.

improvement was less marked in 1953 and for the next two years the survival rates were essentially the same being slightly higher or lower than the control at the various seasons. This was not completely unexpected since antibiotic studies with poultry have given similar results. It has been postulated that feeding antibiotics to a large segment of the experimental animals reduced the general level of infection and resulted in a tapering off of response to antibiotics. Although no significant benefit could be demonstrated from antibiotic supplementation of gestation diets, neither was there any indication of harmful effect.

For 1952 and 1953, the pelleted starter diet as listed in table 1 was made available to one-half of the test litters beginning when the pigs were two weeks old and fed ad lib until weaning at eight weeks. The results (table 3) showed that 56-day weights of pigs which had access to the pelleted starter diet exceeded 56-day weights of pigs which did not receive starter diet by a highly significant ($P<.01$) amount (8 to 14 lb.) in three out of four farrowing seasons. In the fourth season (fall, 1953) the difference was not significant.

During 1954 and 1955 all pigs received the pelleted starter diets. One half of the test litters were fed the diet containing antibiotic-B_{12} concentrate and the control litters received the same diet without antibiotic-B_{12} in order to differentiate between nutritional quality of the starter diet and the antibiotic effect. As shown in table 3, the antibiotic-fed pigs were heavier at 56 days by a highly significant ($P<.01$) amount in one season (spring, 1954) but did not differ significantly in the other two farrowing seasons. These results are within the expected range since it is generally recognized that response to antibiotics is frequently modified by disease level and other environmental stress factors.

Summary

Data on farrowing and weaning performance as affected by level of crude protein and antibiotic supplement in the gestation diet of sows and by certain creep feeding practices have been presented. The experiment included results on 313 litters farrowed in seven farrowing seasons from 1952 through 1955.

The survival rate of baby pigs to 56 days of age, expressed as a percentage of initial litter size, was significantly ($P<.02$) higher from sows receiving the higher (20% or 17.5%) level of crude protein in gestation diets than from sows receiving the control diet at 15% protein.

An apparent improvement in survival rate attributed to antibiotic-vitamin B_{12} supplementation of swine gestation diets in 1952 was not obtained in subsequent farrowing seasons. The relation of stress factors to antibiotic response was discussed briefly.

Ad lib access to a pelleted starter diet containing chlortetracycline and vitamin B_{12} from 14 days of age increased the 56-day weights of suckling

pigs by a highly significant ($P<.01$) amount in 3 of 4 farrowing seasons.

A comparison between the above supplemented starter diet and the same formulation without chlortetracycline-B_{12} concentrate showed a highly significant ($P<.01$) difference in favor of the supplemented diet in the first farrowing season but not in the other two seasons.

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PROTEIN AND FAT REQUIREMENTS OF BABY PIGS [1, 2]

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PRESENT day research in swine nutrition with its early weaning programs and its use of the baby pig in biological assays has necessitated the determination of the nutritional requirements of the baby pig. The requirements for two of these nutrients (protein and fat) have not been clearly established. Early studies on the protein and fat requirements of baby pigs were conducted with liquid synthetic milk diets, which were formulated generally on the basis of the composition of sow milk.

Reber *et al.* (1953) fed synthetic milk diets of varying protein and fat levels to baby pigs and observed that at an early age best performance was obtained from pigs fed 41% protein and 35.7% fat, but as the pigs approached weaning age (56 days) lower levels of protein appeared to be adequate. Sewell *et al.* (1953) reported that satisfactory results were obtained with synthetic milk diets that contained 24% and 28% protein, although the best results were obtained with one containing 32% protein.

Becker *et al.* (1954) compared protein levels from 10.2 to 30.6% for pigs from 1 to 4 weeks of age and from 10 to 25.5% protein for pigs from 5 to 9 weeks of age, and showed that 22.4% and 12% protein diets for the two age groups, respectively, were equal to the higher levels of protein fed. Catron *et al.* (1953) tested liquid synthetic-milk rations containing 10, 20 or 30% fat on baby pigs and observed that with a 15% solids ration, the lowest level of fat (10%) produced the best growth.

Speer *et al.* (1954) developed for early-weaned pigs a dry-pre-starter ration which contained 24% protein and 7% fat. Excellent gains were made by the baby pigs fed this ration. Crampton and Ness (1954) reported an experiment with a dry-meal ration for baby pigs in which they compared two levels of protein and two levels of fat. The greatest gains and feed efficiency were made by the pigs fed the diet containing 30% protein and 8% fat. Hanson *et al.* (1954) were not able to show a significant increase in gains or feed efficiency by the addition of 5.1% of a lard-lecithin mixture to a dry ration for early-weaned baby pigs.

This experiment was conducted to define further the protein and fat requirements of baby pigs fed a dry-meal ration.

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[2] From a portion of a thesis presented by E. R. Peo, Jr., to the Graduate College, Iowa State College, in partial fulfillment of the requirements for the Ph.D. degree, 1956.

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Experimental

Animals. Two hundred seventy-two crossbred (Duroc×Landrace×Poland China) baby pigs, weaned at an average weight of 6.4 lb. and at an average age of 7.9 days, were used in a 4×4 factorial plan (see table 4) of a randomized block design. Each of the 16 ration treatments was tested on three pens of four and one pen of five pigs each for a total of 17 pigs per treatment. Limited housing facilities permitted the testing of only one replication of the 16 ration treatments at any one time. The pigs were allotted, as they became available, to the treatments at random within litters within replication.

TABLE 1. COMPOSITION OF BASAL RATION

Ingredient		Proportion
Carbohydrate Mixture [a]	(Dextrose 50%)	60.50
	(Corn flakes 20%)	
	(Pearl starch 15%)	
	(Sucrose 15%)	
Lard (Stabilized)		0.00
Protein mixture [b]	(Solv. soybean oil meal (50% protein) 50%)	30.00
	(Low-heat, spray-dried skimmilk 50%)	
Corn steep water (liquid basis)		1.00
Dried brewers yeast		0.50
Dried beet pulp		2.00
Calcium carbonate		0.05
Dicalcium phosphate		3.30
Iodized salt		0.50
Trace minerals (Fe, Cu, Co, Mn, Zn) [c]		0.15
Vitamin—antibiotic premix [d]		2.00
	Total	100.00

[a] Fat levels developed by substituting stabilized lard for carbohydrate mixture.

[b] Protein levels developed by varying the proportions of the carbohydrate and protein mixtures.

[c] Supplied the elements in the following amounts for each lb. of complete ration: Fe, 47.7 mg.; Cu, 3.3 mg.; Co, 1.14 mg.; Mn, 40.2 mg. and Zn, 3.0 mg.

[d] Added so that each lb. of complete ration contained the following amounts of vitamins and antibiotics: vitamin A, 5000 I.U.; vitamin D_2, 1000 I.U.; riboflavin, 5 mg.; calcium pantothenate, 10 mg.; niacin, 30 mg.; thiamin, 5 mg.; choline, 450 mg.; folic acid, 8 mg.; pyridoxine, 2 mg.; alpha tocopherol acetate, 10 mg.; vitamin C, 300 mg.; PABA, 8 mg.; vitamin K, 1 mg.; vitamin B_{12}, 20 mcg. and antibiotics, 50 mg.

The temperature of the experimental building was thermostatically held at 70° F. when the pigs were one to three weeks of age, and at 65° F. when they were three to five weeks of age. The pigs were confined to pens that were equipped with self-feeders, automatic water founts and radiant-heated concrete floors. Heat lamps were used in each pen to assure adequate floor temperature for the first two-week test period.

Rations. The 16 ration treatments were derived from four levels of protein (15, 20, 25 and 30%) each fed in combination with four levels of fat (0, 2.5, 5 and 10%). The composition of the basal ration is presented in table 1. It contained 15% protein and no added fat. The calcu-

TABLE 2. GROSS ENERGY VALUES OF EXPERIMENTAL RATIONS AS DETERMINED WITH THE BOMB CALORIMETER [a]

Protein level	Fat levels (%)			
	0	2.5	5	10
%	Kcal./per gm.			
15	3.92	3.98	4.05	4.18
20	3.86	4.03	4.15	4.37
25	4.11	4.16	4.32	4.54
30	4.10	4.18	4.31	4.52

[a] Each value is the average of duplicate samples.

lated fat content was 0.45%. The protein was supplied by a mixture of equal proportions of solvent soybean oil meal (50% protein) and low-heat, spray-dried skimmilk (34% protein). Stabilized lard was used as the source of fat. The gross energy values of the experimental rations as determined by the bomb calorimeter are presented in table 2. The pigs were fed the experimental rations and remained on test for 28 days.

Analysis of the data. The data were analyzed statistically using the pen of pigs as the experimental unit and the average pig response as the observation. The analysis of variance scheme and a summary of the mean squares for gains and feed efficiencies are presented in table 3. All statements concerning statistical significance of ration treatment effects are at a probability level of 5% or less.

TABLE 3. ANALYSIS OF VARIANCE FOR GAIN AND FEED PER POUND OF GAIN

Source of variation	Degrees of freedom	Mean squares			
		Two-weeks		Four-weeks	
		Gain	F/G	Gain	F/G
Replications	3	3.6167	0.6513	69.6777	0.7785
Fat levels	3				
Linear regression component	1	1.0588	1.4055	7.9325	0.0007
Quadratic regression component	1	0.0114	0.7782	1.5250	0.0052
Cubic regression component	1	0.1228	0.0126	0.6841	0.0889
Protein levels	3				
Linear regression component	1	12.2070	7.8344	20.6553	1.2550
Quadratic regression component	1	2.2877	2.0556	16.9127	0.3108
Cubic regression component	1	2.5353	0.2935	27.0820	0.0714
Fat levels x protein levels	9	0.3300	0.2210	4.0802	0.0419
Experimental error	45	0.6041	0.2376	3.3642	0.0353
Total	63				

Results and Discussion

In the analysis of the data the mean squares for the interactions (9 degrees of freedom, table 3) of the protein and fat effects on gain and feed required per pound of gain were tested against the error mean squares for statistical significance. Also the sum of squares for the 9 degrees of freedom associated with these interactions were subdivided into individual component parts (protein linear × fat linear, etc.) and tested against the error mean squares. None of the "F" ratios obtained were significant thus the data are discussed mainly in terms of main effects (protein and fat) rather than in terms of interactions.

TABLE 4. FIRST TWO-WEEK TEST PERIOD. GAIN AND FEED EFFICIENCIES FOR BABY PIGS FED RATIONS VARYING IN LEVELS OF PROTEIN AND FAT (LB. PER PIG)

Items	Protein level	Fat levels (%)				
		0	2.5	5	10	(Av.) [b]
	%					
Gain	15	2.95[a]	3.30	2.75	2.48	2.87
	20	3.90	4.10	4.20	3.78	3.99
	25	4.18	3.62	3.92	3.68	3.85
	30	4.48	4.40	3.70	4.30	4.22
	Av.	3.88	3.85	3.64	3.56	
						(Av.) [c]
Feed/lb. gain	15	2.33	2.52	3.20	3.30	2.84
	20	1.82	2.12	1.99	2.26	2.05
	25	1.68	2.05	2.05	1.85	1.91
	30	1.64	1.84	2 12	1.75	1.84
	Av.[d]	1.87	2.13	2.34	2.36	

[a] These values are averages for 17 pigs.
[b] Protein cubic regression significant at P=0.05 or less.
[c] Protein quadratic regression significant at P=0.05 or less.
[d] Fat linear regression significant at P=0.05 or less.

First Two-Week Test Period

Summaries of the gain and feed efficiency data for this period are presented in table 4.

Gains. On the average, as the protein levels were increased the greater gains observed in the pigs were statistically significant. A statistically significant cubic regression component indicates that the depression of gains at the 25% protein level is not just a chance result. When the average feed consumption data are considered (feed per gain × gain, table 4), they show that at this level of protein the pigs on 2.5, 5 and 10% fat failed to consume as much feed as the pigs fed the corresponding fat levels with the 20% level of protein. While this may be partially responsible for the reduced gains on the 25% level of protein, the authors are unable

to offer a plausible explanation for this decreased feed intake which was fairly consistent over the four replications. This consistency suggests that some factor other than chance was responsible for the decreased feed intake. The observation that the 30% protein rations produced fastest gains is in agreement with the work of Reber *et al.* (1953) and Becker *et al.* (1954) which showed that, initially, the protein requirement of the baby pig is high.

The inverse relationship observed between level of fat in the ration and gains (averaged across all levels of protein) was not statistically significant. Certainly the inclusion of 5 or 10% fat in the rations did not improve gains over the zero percent fat level. As mentioned previously, the zero percent fat rations were calculated to contain 0.45% fat, a level which, according to the work of Shrewsbury and Vestal (1946) with older pigs, should be limiting. However, in this experiment the only drawbacks encountered with the rations containing zero percent fat were dustiness of the feed and encrustation of the pigs' hair coat with feed particles. These drawbacks were eliminated when the fat level in the ration was 2.5% or above.

Feed per lb. gain. The feed utilization improved markedly as the protein in the ration was increased from 15 to 20%, and continued to improve at a decreasing rate as the protein was increased to 30% with the result that the quaratic regression component was statistically signficant. In contrast to this, and perhaps contrary to what might be expected, the feed efficiencies decreased as the level of fat was increased in the rations. When averaged across all protein levels, this depressing effect on feed utilization was statistically significant.

Thus, considering both gain and feed efficiency, the data of table 4 show that the combination of the highest level of protein and the lowest level of fat produced the best results for the two-week test period.

Four-Week Test Period

The four-week gain and feed efficiency data are presented in table 5.

Gains. The gains of the pigs fed that 15% protein rations were less than those of the pigs fed 30% protein, for all four levels of fat. When considering the fat levels individually, gains on 2.5 and 5% fat increased as the protein level of the ration increased from 15 to 20%. Further increases in protein resulted in decreased gains with these levels of fat. In contrast to this, maximum gains were observed on zero and 10% fat at the 30% level of protein. However, this apparent protein $\times$ fat interaction was not statistically significant.

There was a depression in the gain curves of the pigs fed these levels of fat (zero and 10%) at the 25% protein level. These two depressions were of sufficient magnitude that when the gains were averaged across all fat levels, the value of 13.8 lb. gain at the 25% protein level was a

statistically significant departure from a quadratic response of gain to protein level. For the entire test period, the greatest gains were made by the pigs fed 20% protein with 2.5% fat. However, when considering the overall averages of fat and protein, gains were maximum on zero percent fat (14.2 lb.) and 20% protein (15.0 lb.)

Feed per lb. gain. When the values for feed required per lb. of gain were averaged across all fat levels, the observed responses showed a marked increase in feed efficiency when the protein in the ration was increased from 15 to 20%. The feed efficiency remained fairly constant, however, with

TABLE 5. FOUR-WEEK TEST PERIOD. GAIN AND FEED EFFICIENCIES FOR BABY PIGS FED RATIONS VARYING IN LEVELS OF PROTEIN AND FAT (LB. PER PIG)

Items	Protein level	Fat levels (%)				
		0	2.5	5	10	Av.[b]
	%					
Gain	15	13.10[a]	12.97	12.62	10.70	12.35
	20	14.92	16.05	15.35	13.87	15.05
	25	13.67	13.87	14.85	12.85	13.81
	30	15.17	13.25	13.87	15.52	14.45
	Av.	14.21	14.03	14.17	13.23	
						Av.[c]
Feed/lb. gain	15	2.06	2.16	1.99	2.20	2.11
	20	1.77	1.81	1.69	1.86	1.78
	25	1.76	1.67	1.74	1.82	1.75
	30	1.69	1.89	1.69	1.53	1.70
	Av.	1.82	1.88	1.78	1.85	

[a] These values are averages for 17 pigs.
[b] Protein cubic regression significant at P=0.05 or less.
[c] Protein quadratic regression significant at P=0.05 or less.

further increases in the protein level. This quadratic response was statistically significant. On the average, there was little effect of fat levels on feed efficiency.

Summary

Four protein and four fat levels were studied in a 4×4 factorial experiment with 272 baby pigs fed dry-meal rations to determine the effect of protein and fat levels on gains and feed efficiency.

Response to protein levels (15, 20, 25 or 30%) for the first two-week test period showed a significant linear regression with maximum gains occurring on 30% protein. For the four-week test period, the observed gains when averaged across all fat levels (0, 2.5, 5.0 and 10%) reached a maximum on the 20% protein rations.

There was no significant difference in gains attributable to fat levels

for either the first two-week or the four-week test period. However, when fat was added to the rations, the appearance of the pigs was improved. Fat also improved the physical characteristics of the ration.

Feed efficiency was significantly improved by increasing protein levels for both the first two-week and the four-week test periods. With increasing levels of fat, a significant linear decrease in feed efficiency occurred for the first two-week test period, but there was no significant difference in feed efficiency due to fat for the four-week test period.

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THE INFLUENCE OF CALCIUM PANTOTHENATE, TRYPTOPHAN AND METHIONINE SUPPLEMENTATION, AND SOURCE OF PROTEIN UPON PERFORMANCE OF GROWING SWINE FED CORN-MEAT AND BONE SCRAPS RATIONS[1]

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SEVERAL investigations have recently been conducted in which meat and bone scraps, or similar material, were used as the main source of supplemental protein to corn in swine rations. It is apparent from the reports of Williams (1955) and the National Research Council (1953) that corn-meat and bone scrap diets containing 12 to 16% of crude protein are deficient in tryptophan and pantothenic acid.

Luecke *et al.* (1949, 1952) and Henson *et al.* (1954) have demonstrated pantothenic acid deficiency in growing swine fed diets composed of natural feedstuffs. Improved rate of gain and alleviation of pantothenic acid deficiency symptoms was effected by calcium pantothenate supplementation.

Typical corn-meat and bone scraps rations containing 15 to 16% protein will contain approximately 0.10% tryptophan which is less than the 0.13% level suggested as adequate for 40 to 100 lb. pigs by Becker *et al.* (1954a).

Henson *et al.* (1954) indicated that the 14.5% protein corn-meat scraps diet used in their investigations contained 0.44% methionine plus cystine. This was less than the required level of 0.3% DL-methionine in the presence of 0.3% cystine reported as necessary by Shelton *et al.* (1951). Typical corn-meat and bone scraps diets containing 14% crude protein will contain approximately 0.26% methionine which is in excess of the level of 0.23% of diet suggested by Becker *et al.* (1954a) to be adequate for growing swine. Becker *et al.* (1954b) had previously reported that an estimated 0.46% total methionine and cystine was adequate for 5 to 9 week old pigs, perhaps indicating that the total sulfur amino acid requirement is less than previously reported.

These studies were conducted to obtain further information on the influence of calcium pantothenate, tryptophan and methionine supplemen-

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tation of 16.6 and 16.0% crude protein corn-meat and bone scraps rations upon performance of growing-fattening pigs.

The ability of meat and bone scraps obtained from different sources to satisfactorily meet the protein and amino acid needs of growing pigs was also investigated.

Procedure

Experiment 1. Fifty-four thrifty weanling purebred Duroc and Hampshire × Duroc pigs averaging approximately 39 lb. were randomly allotted to nine lots of six pigs each. The basal ration contained 16.6% protein and was formulated from 80.5 parts of ground yellow corn, 19.0 parts of a blend of equal parts of 4 brands of commercially available 50% protein meat and bone scraps and 0.5 part of iodized salt. Non-protein dietary factors consisting of 2000 I.U. vitamin A, 100 I.U. vitamin D, 1 mg. riboflavin, 10 mg. niacin, 100 mg. choline chloride, 5 mg. chlortetracycline, 15 mg. iron, 4 mg. manganese, 1.5 mg. copper, 1.5 mg. zinc, and 0.5 mg. of cobalt per pound of mixed ration were added.

The basal ration was supplemented with 0, 0.04 and 0.08% of DL-tryptophan and/or 0, 1 and 2 mg. of calcium pantothenate per pound of mixed ration, making a total of nine experimental treatments. This experimental design provided a total of 18 pigs on each experimental level of tryptophan as well as of pantothenic acid. All rations were self-fed over a 42-day experimental period. Each lot of pigs was maintained in a concrete-floored pen which was equipped with an automatic waterer.

Experiment 2. The value of DL-tryptophan and DL-methionine supplementation of a 16% crude protein corn-meat and bone scraps ration was studied, using heavyweight weanling pigs. Fifty-four, 8.5-week old Hampshire × Duroc pigs averaging approximately 44 lb. were randomly allotted to provide six pigs on each of nine experimental treatments. The experiment was conducted over a 53-day period.

The basal ration was formulated from 85.5 parts of ground yellow corn, 14 parts of a blend of equal parts of 4 commercially available brands of 50% protein meat and bone scraps and 0.5 parts of iodized salt. This ration was supplemented with 2000 I.U. vitamin A, 100 I.U. vitamin D, 1 mg. riboflavin, 5 mg. niacin, 4 mg. calcium pantothenate, 5 mg. chlortetracycline, 15 mg. iron, 8 mg. manganese, 1.5 mg. zinc, 1.5 mg. copper and 0.5 mg. cobalt per pound of complete mixture. The corn used in the basal ration contained 10.75% protein. Levels of 0.098 and 0.27% of tryptophan and methionine, respectively, were determined to be present in the basal ration by amino acid assays carried out on the basic ingredients.

Supplementations of 0, 0.04 and 0.08% of DL-tryptophan and 0, 0.05 and 0.10% of DL-methionine were made in all possible combinations. Thus, nine experimental treatments were used, and a total of 18 pigs was fed on each experimental level of each test amino acid. All pigs were maintained

in concrete floored pens throughout the 53-day experimental period. They were individually fed the experimental diets twice daily to limit of appetite.

Experiment 3. Eighty Hampshire × Yorkshire and purebred Yorkshire pigs averaging approximately 40 lb. were randomly allotted to eight lots of ten pigs each. Each lot of pigs was maintained in a concrete floored pen equipped with an automatic waterer and a self-feeder. Experimental rations, the composition of which is shown in table 3, were self-fed for a 56-day period.

Meat and bone scraps were obtained from several sources and separate samples were tested (treatments 1, 2, 3 and 4) for their ability to promote equivalent performance in growing pigs. A combination of equal parts of meat and bone scraps obtained from four different packing plants was used for treatment 5. For treatment 6, a combination of 1 part of rendering plant meat and bone scraps and 1 part of the blend used for treatment 5 was employed. Meat and bone scraps of the blend used for treatment 5 supplied one-half of the supplemental protein for treatments 7 and 8. Either blood meal or solvent soybean oil meal supplied the remaining supplemental protein as indicated in table 3. Replacement of a part of the supplemental protein from meat and bone scraps with protein of another source did not greatly alter the amino acid composition of the rations with the exception of tryptophan. This approach was intended to supply some information on differences in pig performance due to possible differences in availability of amino acids in the various diets.

Results and Discussion

Experiment 1. The results of tryptophan and calcium pantothenate supplementation of the basal ration are shown in table 1. Data for this experiment, and other experiments reported herein have been analyzed by covariance (Snedecor, 1946). Final pig weights have been adjusted on the basis of initial weights of the individual pigs and significant differences, if any, are based upon the final pig weights.

As has been reported by other investigators (Bloss *et al.*, 1953; Terrill *et al.*, 1954; and Henson *et al.*, 1954) trytophan supplementation of typical corn-meat and bone scraps type rations caused a highly significant ($P<0.01$) increase in gains of pigs. No significant increase in final pig weight resulted from calcium pantothenate supplementation of the basal diet. There was no significant interaction between tryptophan and pantothenic acid.

Although highly significant increases in final pig weights resulted from tryptophan supplementation of the ration, none of the final pig weights is considered to be satisfactory for pigs of the size and age used in this study. This failure to obtain satisfactory rate of gain with a dietary regimen such as used in this experiment strongly suggests that a lack or excess, e.g. calcium, of dietary factors other than tryptophan may have

impaired pig performance as measured by pig gain and efficiency of feed utilization.

Experiment 2. The results of tryptophan and methionine supplementation of the basal ration upon gain and efficiency of feed utilization of

TABLE 1. INFLUENCE OF DL-TRYPTOPHAN AND CALCIUM PANTOTHENATE SUPPLEMENTATION OF SWINE RATIONS ON PIG PERFORMANCE, EXPERIMENT 1

Item	Percent DL-tryptophan added			Performance by Ca. pantothenate level
	0	0.04	0.08	
0 additional Ca. pantothenate				
Number of pigs	6	6	6	18
Av. initial wt., lbs.	41.33	35.83	38.33	38.50
Av. adjusted final wt., lb.[a]	70.64	86.02	82.59	79.75
Av. daily gain, lb.[b]	0.85	1.08	1.05	1.00
Feed/lb. gain, lb.	3.48	3.22	3.54	3.41
2 mgm. additional Ca. pantothenate/lb. diet				
Number of pigs	6	6	6	18
Av. initial wt., lb.	38.50	35.50	35.50	36.50
Av. adjusted final wt., lb.[a]	68.75	87.37	85.04	80.22
Av. daily gain, lb.[b]	0.74	1.11	1.04	0.96
Feed/lb. gain, lb.	3.53	3.20	3.32	3.33
4 mgm. additional Ca. pantothenate/lb. diet				
Number of pigs	6	6	6	18
Av. initial wt., lb.	39.00	39.68	39.50	39.39
Av. adjusted final wt., lb.[a]	66.06	87.53	90.38	81.32
Av. daily gain, lb.[b]	0.69	1.21	1.24	1.05
Feed/lb. gain, lb.	3.68	3.38	3.31	3.41
Performance by tryptophan level				
Number of pigs	18	18	18	
Av. initial wt., lb.	39.61	37.00	37.78	
Av. adjusted final wt., lb.[a]	68.69	86.98	85.82	
Av. daily gain, lb.[b]	0.76	1.13	1.11	
Feed/lb. gain, lb.	3.56	3.27	3.39	

[a] Average final weight plus correction factor obtained by multiplying deviation from the mean (38.13) by regression coefficient (2.04). Snedecor (1946).
[b] Unadjusted average daily gains.

growing pigs are summarized in table 2. The addition of DL-tryptophan resulted in the expected highly significant ($P<0.01$) increase in final pig weights and the addition of 0.10% of DL-methionine alone caused a marked, but not significant, depression in average final weight of pigs.

There were no significant differences in final pig weights due to DL-methionine supplementation, nor was there significant tryptophan $\times$ methionine interaction. The marked reduction in final pig weights which

resulted when 0.1% of DL-methionine was added in the absence of supplemental DL-tryptophan was not apparent when either level of supplemental DL-tryptophan was added.

It is difficult to explain the depression in final weights of pigs due to the addition of methionine. With the exception of the tryptophan content, this

TABLE 2. INFLUENCE OF DL-TRYPTOPHAN AND DL-METHIONINE SUPPLEMENTATION OF SWINE RATIONS ON PIG PERFORMANCE, EXPERIMENT 2

Item	Percent DL-tryptophan			Performance by methionine level
	0	0.04	0.08	
0 percent DL-methionine added				
Number of pigs	6	6	6	18
Av. initial wt., lb.	44.50	43.33	43.67	44.06
Av. adj. final wt., lb.[a]	66.57	91.59	83.43	80.53
Av. daily gain, lb.[b]	0.43	0.87	0.74	0.68
Feed/lb. gain, lb.	4.04	3.05	3.23	3.44
0.05% DL-methionine added				
Number of pigs	6	6	6	18
Av. initial wt., lb.	43.67	44.00	44.83	44.18
Av. adj. final wt., lb.[a]	74.19	86.15	87.18	82.89
Av. daily gain, lb.[b]	0.55	0.79	0.82	0.70
Feed/lb. gain, lb.	3.31	3.21	3.10	3.20
0.10% DL-methionine added				
Number of pigs	6	6	6	18
Av. initial wt., lb.	43.67	44.83	44.83	44.44
Av. adj. final wt., lb.[a]	59.86	86.18	94.32	80.12
Av. daily gain, lb.[b]	0.29	0.81	0.96	0.69
Feed/lb. gain, lb.	5.51	3.34	3.02	3.96
Performance by tryptophan level				
Number of pigs	18	18	18	
Av. initial wt., lb.	43.94	44.06	44.67	
Av. adj. final wt., lb.[a]	66.88	87.96	88.31	
Av. daily gain, lb.[b]	0.42	0.81	0.84	
Feed/lb. gain, lb.	4.28	3.20	3.12	

[a] See footnote 1, table 1. Regression coefficient, 2.16; mean initial weight, 44.22.
[b] Unadjusted average daily gains.

diet contained as much or more of other essential amino acids as did diets which gave satisfactory nitrogen retention by growing pigs in other trials at this station (Meade, 1956a, 1956b). The addition of 0.1% of methionine to the basal diet may have created an amino acid imbalance which was expressed as a decrease in rate of weight increase of the pigs. Harper (1956) suggested that an amino acid imbalance could exist when "(1) a detrimental effect (e.g., growth depression) is observed when the diet of animals receiving a suboptimal supply of essential amino acids is supplemented with amino acids as protein; (2) this effect is prevented by a small supplement

of the amino acid that is most limiting for the process being studied". Tryptophan would have been the most limiting amino acid in the diet used in these studies. Depression in pig weights due to methionine supplementation of the diet was overcome when tryptophan was added to the diet. Salmon (1954) suggested that for incomplete proteins, a supplement of the second most limiting amino acid leads to an increased rate of catabolism of all amino acids, and thereby to an increased loss of the most limiting. It appears that either methionine or isoleucine was the second most limiting amino acid in the diet used in this study. Harper (1956) cites several research reports where supplementation of the diet with the second most limiting amino acid for growth caused a depression in growth of rats which could be overcome by supplementation with tryptophan, the most limiting amino acid. Differences in adjusted final mean weights of pigs on either level of supplemental DL-tryptophan do not indicate any real difference due to level of supplementation.

The calculated amino acid content of the diets which gave the greatest average final pig weights was 0.118 to 0.138% of tryptophan, if the D-isomer is completely unavailable, and 0.27 to 0.32, 0.80, 0.57, 0.36, 1.81, 0.69, 0.51 and 0.73% of methionine, lysine, isoleucine, histidine, leucine, phenylalanine, threonine and valine, respectively. If all amino acids were completely available, and if no other dietary factors were limiting, pigs such as those used in this study should have reached much greater final weights than were realized.

Although highly significant differences in final weights due to treatment have been reported, none of the adjusted final weights is considered to be satisfactory. Lightweight (average weight approximately 30 lb.) littermates of the pigs used in this study gained at rates closely approximating 1.7 lb. daily over a 98-day feeding period when fed a 16% crude protein all plant ration complete in known dietary factors. The possibility that the processing method may have adversely affected the meat and bone scraps insofar as release of essential amino acids is concerned cannot be overlooked. Bissett and Tarr (1954) have reported that heat treatment may adversely affect the release of essential amino acids from fish meal.

Experiment 3. Data relative to the amino acid composition of the rations (table 3) indicate that source of protein had some influence on the amino acid content of the diet. The main difference in amino acid content of the various diets relates to tryptophan. Larger amounts of tryptophan were present in the rations in which a part of the supplemental protein was supplied by blood meal or soybean oil meal. However, fairly wide differences in tryptophan content of the various rations also resulted due to source of meat and bone scraps.

Although highly significant ($P<0.01$) differences in final pig weight resulted due to treatment no attempt was made to locate specific differences. It would appear that the 13% increase in final weight of pigs fed the ration containing 0.074% of tryptophan over that of pigs fed the diet

containing 0.092% of tryptophan must have been due in part to availability of essential amino acids. Final weights of pigs fed the rations containing from 0.10 to 0.11% of tryptophan differed as much as 11%, again suggesting that some differences in availability of essential amino acids must have existed.

TABLE 3. COMPOSITION OF RATIONS AND INFLUENCE OF RATION UPON PERFORMANCE OF GROWING PIGS, EXPERIMENT 3

Ingredient [a]	Treatment							
	1	2	3	4	5	6	7	8
Ground yellow corn	82.0	82.0	82.0	82.0	82.0	82.0	85.5	80.5
Meat and bone scraps	17.5	17.5	17.5	17.5	17.5	17.5	9.0	9.5
Blood meal	....	....	....	....	....	....	5.0	....
Solvent soybean oil meal	....	....	....	....	....	....	....	9.5
Iodized salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin-antibiotic-trace element mixture [b]	+	+	+	+	+	+	+	+
Percent crude protein	16.8	16.9	16.7	17.0	16.8	16.8	16.7	16.8
Amino acid content, % of diet [c]								
Tryptophan	0.11	0.092	0.101	0.074	0.104	0.103	0.127	0.126
Lysine	0.73	0.77	0.76	0.78	0.76	0.76	0.85	0.79
Methionine	0.36	0.35	0.40	0.36	0.36	0.37	0.35	0.36
Isoleucine	0.76	0.76	0.55	0.72	0.75	0.75	0.65	0.86
Leucine	2.12	2.17	2.16	2.12	2.17	2.17	2.43	2.26
Histidine	0.37	0.39	0.40	0.40	0.41	0.40	0.53	0.44
Phenylalanine	0.75	0.74	0.74	0.75	0.76	0.75	1.06	0.84
Threonine	0.67	0.69	0.72	0.68	0.68	0.68	0.70	0.71
Valine	0.93	0.93	0.91	0.93	0.96	0.93	1.06	1.09
Arginine	1.00	1.12	1.03	1.10	1.03	1.03	0.89	1.10
Number of pigs/treatment	10	10	10	10	10	10	10	10
Av. initial wt., lb.	40.2	38.9	42.2	38.8	42.1	40.9	40.6	39.3
Av. adj. final wt., lb.[d]	89.0	74.6	82.3	84.2	88.1	81.5	106.9	111.0
Av. daily gain, lb.[e]	0.88	0.59	0.77	0.75	0.87	0.74	1.19	1.25
Feed/lb. of gain, lb.	3.91	4.41	3.56	4.50	3.41	3.71	3.01	2.72

[a] Composition of ration based on pounds of air dry feed.
[b] Furnished 1 mg. riboflavin, 4 mg. calcium pantothenate, 10 mg. niacin, 2000 I.U. vitamin A, 100 I.U. vitamin D, 10 mg. chlortetracycline, 15 mg. iron, 8 mg. manganese, 1.5 mg. zinc, 1.5 mg. copper and 0.5 mg cobalt per pound of total ration
[c] Amino acid assays on basic ingredients supplied through the courtesy of Dr. R. O. Nesheim, The Quaker Oats Company, Chicago, Illinois.
[d] See footnote 1, table 1. Regression coefficient 1.59; mean initial weight, 40.38.
[e] Unadjusted average daily gains.

The use of either solvent soybean oil meal or blood meal as a source of part of the supplemental protein resulted in differences as great as 48% in final pig weight. The use of these sources of supplemental protein did not alter the amino acid content of the rations greatly, except for tryptophan. When the magnitude of the response to tryptophan supplementation of corn-meat and bone scraps rations is considered (Experiments 1 and 2) it appears possible that not all of the response resulting from protein source was due to increased tryptophan content alone. Instead, it appears that additional amounts of some of the essential amino acids may have been available from the other sources of protein.

As is shown in tables 1 and 2, the use of rations low in tryptophan (Experiments 1 and 2) contributed to a reduced efficiency of feed utilization. This trend is even more marked where rations formulated with meat and bone scraps from different sources and containing low levels of tryptophan were used. Pigs fed the lower tryptophan corn-meat and bone scraps rations required as much as 26% more feed per unit of gain. These differences in efficiency of feed utilization were exaggerated even more when another source of protein was included in the ration with resultant change in the essential amino acid content. Rations which appeared to be more nearly adequate produced gains on from 39 to 66% less feed per unit of gain.

It is realized that a mineral imbalance may have existed in all rations due to the use of meat and bone scraps as the main source of supplemental protein. Many of the diets could have contained as much as 2.0% of calcium and it has long been recognized that excessive calcium will depress growth of pigs. In the first two experiments (Experiment 1 and 2) this condition would have been essentially the same for all treatments. Although excessive calcium may have contributed to the depressed performance of animals receiving only meat and bone scraps as supplemental protein, those rations containing soybean meal and blood meal contained well above the requirements of pigs of the weight used in the last experiment. Furthermore, the results of the earlier experiments (Experiments 1 and 2) definitely indicate that a tryptophan response can be obtained from high calcium low tryptophan diets.

Summary

Supplementation of 16.6 and 16.0% crude protein corn-meat and bone scraps rations with 0.04 and 0.08 DL-tryptophan caused a highly significant increase in final weights of pigs fed the experimental rations over 42 or 53 day periods. Neither methionine nor calcium pantothenate supplementation of the basal ration resulted in increased final pig weights, nor was there a significant interaction between either of these nutrients and DL-tryptophan.

Final pig weights were unsatisfactory although the rations were formulated to be adequate in other known dietary factors. Although experimental rations as supplemented should have been adequate to promote maximum pig growth, except for excessive calcium, it appears that all essential amino acids determined to be in the ration may not have been available to the pig.

Use of separate samples of meat and bone scraps, containing essentially the same amount of crude protein, as protein supplements to corn resulted in large differences in final pig weights. These results suggest differences in availability of amino acids from meat and bone scraps of different sources. Substitution of solvent soybean oil meal and of blood meal for one-half of the supplemental protein supplied by meat and bone scraps caused marked increases in final weight of pigs. A part of this difference

in pig performance appeared to be due to the lack of availability of essential amino acids in the meat and bone scraps diets and an increase in the availability of these amino acids from the other supplemental protein sources. The use of rations which appeared to be more nearly adequate in the essential amino acids caused marked improvement in efficiency of feed utilization. The possibility that excessive dietary calcium may have interfered with pig performance was also discussed.

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SUBCUTANEOUS STIBESTROL IMPLANTATION IN GROWING-FATTENING SWINE

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ALTHOUGH Braude (1947) first reported that the feeding of 50 mg. of diethylstilbestrol (stilbestrol) daily to young castrate male pigs would produce a slight increase in growth rate, later investigations seem to indicate few, if any, beneficial effects on growth (Beeson *et al.*, 1955; Taylor *et al.*, 1955; Sewell *et al.*, 1957). Similarly, the subcutaneous implantation of stilbestrol either as a single dose (Dinnuson *et al.*, 1951; Murphree *et al.*, 1951) or as more than one dose (Woehling *et al.*, 1951; Pearson *et al.*, 1952) did not increase rate of gain in barrows and gilts. Sleeth *et al.*, (1953) studied the effects of semi-weekly intramuscular injections of estradiol benzoate on the growth rate of barrows and gilts. This treatment, likewise, did not significantly affect average daily gain. In swine, it appears that the failure to show an effect on weight increase is not related to the mode of frequency of administration.

In a few trials, although the differences were not always significant, a reduction of feed required per 100 lb. of gain has been reported following estrogen administration (Braude 1947; Dinnuson *et al.*, 1951).

Estrogen treatment in sheep and cattle results in a reduction of fat and an increase in protein (Clegg and Cole, 1954; Clegg and Carroll, 1956). These effects have not been observed by most investigators in swine following stilbestrol (Woehling *et al.*, 1951; Pearson *et al.*, 1952) or estradiol benzoate administration (Sleeth *et al.*, 1953). In one exception, Beeson *et al.* (1955) reported that feeding 2 mg. of stilbestrol in combination with an antibiotic, oxytetracycline, resulted in decreased backfat and belly weight.

The suggested increased efficiency of gain and reduction in fat reported in a few instances following stilbestrol administration are intriguing. These effects might suggest that stilbestrol exerts a protein anabolic effect in swine as it does in ruminants. In order to determine whether these effects do occur, a study on the effects of stilbestrol implantation in swine was undertaken. It is the purpose of this paper to report results of experiments designed to study further the effect of estrogen treatment on gains, feed efficiency, and composition of gains of swine.

Materials and Methods

Four separate trials have been completed involving a total of 136 hogs. These were purebred Duroc barrows, except in trial 1 where 16 Duroc

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gilts were included. In the various trials, the initial weights fell into either of two groups—light weight feeders, averaging 65 lb., or heavy weight feeders, averaging 120 lb.

These animals were full-fed standard rations [2] which supplied 16–17% crude protein up to weights of 150 lb. and 13.5% thereafter to market weight. In trial 3, after about 30 days, a few animals showed symptoms of parakeratosis. All animals were treated with 100 ppm. of zinc as zinc carbonate, and after that time zinc carbonate or zinc sulphate was regularly included in the rations to supply 100 ppm. zinc.

Two or four 15 mg. stilbestrol pellets were implanted subcutaneously in the ear depending on the size of dose, and in one trial half pellets (approximately 7.5 mg.) were used. In trial 2, one lot was implanted similarly with pellets containing 10 mg. estradiol and 250 mg. progesterone. The tables show weights at time of treatment and dose levels employed.

In trials 1 and 2 the animals were group-fed so that no statistical analysis of feeding data is possible. In trials 3 and 4 control and treated animals were subdivided into smaller groups so that feed consumption data could be treated statistically.

Carcasses were broken down the day following slaughter. Dressing percentage was based on cool dressed weight of shipper style carcasses. Carcass length and backfat thickness were determined according to standard methods and represent the distance between the anterior surface of the first rib and the aitch bone and an average of three measurements made opposite the first and last ribs and last lumbar vertebrae, respectively. The eye muscle of the 10th rib was traced and its area measured with a planimeter.

The cuts of meat represent standard wholesale cuts in this area. Standard, heavy fat trim was applied. Density was determined by weighing the entire carcass and untrimmed cuts in air and in water.

Results

Visible effects due to stilbestrol implants were quite evident and developed by 1 to 2 days. These consisted of edematous, hyperemic vulvae in gilts and enlarged teats in both barrows and gilts. A number of teats were excised from barrow carcasses, and the average weight per teat was 0.14 gm. and 0.44 gm. for control and treated barrows, respectively. Coincident with the enlarged vulvae and teats, there was a definite increase in sexual activity as evidenced by continual mounting among barrows and among gilts. After a month, although the extreme swelling and hyperemia had regressed, the vulvae were still enlarged. In 56 barrows treated with 30 mg. or more stilbestrol, there was one mild case of rectal prolapse

[2] Ground barley, 80–86%; Meat and bone scraps (50% protein), 6–7.5%; Alfalfa meal, 5%; Soybean oil meal, 1–3.5%; Cottonseed oil meal, 1–3.5%; Oystershell flour, 0–0.5%; and Salt, 0.5%. Zinc, 100 ppm, was added during the last 64 days of trial 3 and throughout trial 4.

which occurred 9 days after implantation. In the 8 treated gilts no case of vaginal prolapse was observed.

There were other changes evident at slaughter. In trial 1 the ovaries of control gilts averaged 4.15 gm., while those of the treated gilts were either atrophied (1.03 gm. average) or enlarged and cystic (average 48.0 gm.). No intermediate effect was observed. The enlarged ovaries from treated

TABLE 1. RESULTS, TRIAL 1 (68 DAYS)

Lot Number	1A	1B	2A	2B
	Controls		Stilbestrol [a]	
Animals	barrows	gilts	barrows	gilts
Number animals	4	8	4	8
Initial weight, lb.	106.5	110.5	108.0	108.3
Total gain, lb.	101.7	107.1	101.5	108.7
Average daily gain, lb. per pig	1.50	1.57	1.49	1.60
Average daily feed, lb. per pig	6.84		6.84	
Feed per pound gain, lb.	4.41		4.37	
Number carcasses studied	4	6	4	5
Carcass length, cm.	73.5	75.5	73.7	73.5
Backfat thickness, mm.	41.0	36.8	35.5	37.6
Dressing percentage, %	77.5	76.7	78.4	77.0
Loin area 10th rib, sq. in.	3.39	3.87	4.06**	4.19[b]
Trimmed Ham, Loin & Shoulder (HLS), %	45.9	46.8	47.9	48.3
Trimmed Ham (H), %	17.3	18.1	18.1	18.0
Trimmed Loin (L), %	13.0	13.5	13.2	13.4
Trimmed Shoulder (S), %	15.5	15.1	16.5	16.8**[b]
Trimmed Belly (B), %	11.3	10.9	10.9	10.5
Trimmed Ham, Loin & Shoulder (HLS), kg.	32.36	34.03	34.19	34.15
Trimmed Ham (H), kg.	12.19	13.08	12.92	12.76
Trimmed Loin (L), kg.	9.18	9.76	9.48	9.50
Trimmed Shoulder (S), kg.	10.99	11.19	11.80*	11.88[c]
Trimmed Belly (B), kg.	8.04	7.91	7.89	7.43

[a] Implanted in ear at start of trial.
[b] Difference between lots 2A and B combined, and lots 1A and B combined is statistically highly significant ($P<0.01$).
[c] Difference between lots 2A and B combined, and lots 1A and B combined is statistically significant ($P<0.05$).
* Difference from corresponding sex lot 1 statistically significant ($P<0.05$).
** Difference from corresponding sex lot 1 statistically highly significant ($P<0.01$).

gilts showed an absence of corpora lutea but contained varying numbers of large follicles ranging in size from 1.5 to 3 cm. in diameter. The seminal vesicles of the control barrows averaged 1.3 gm. as compared to 20.3 gm. in those treated.

In trial 1, two lots of hogs were used with initial weights of about 110 lb. There were 4 barrows and 8 gilts in each lot. One group was implanted with 30 mg. stilbestrol, and both groups were fed out in a 68-day experiment (table 1). There were no differences in gain, carcass length, or backfat

thickness. The eye muscle area at the 10th rib was 3.68 and 4.13 sq. in. for the control and treated hogs, respectively. This difference was significant at the 1% level. The percentage and weight of trimmed shoulder were also significantly greater in the treated hogs.

Trial 2 was initiated to repeat trial 1 using two additional lots—one treated with a smaller dose of stilbestrol (7.5 mg., lot 2) and another treated with 10 mg. of estradiol and 250 mg. of progesterone (lot 4). The

TABLE 2. RESULTS, TRIAL 2 (82 DAYS, 12 BARROWS PER LOT)

Lot number	1	2	3	4
		Stilbestrol [a]		10 mg. Estradiol and 250 mg. progesterone[a]
Treatment	Controls	7.5 mg.	30 mg.	
Weight at treatment, lb.	—	60.7	60.7	60.3
Initial weight, lb.	61.5	60.7	60.7	60.3
Total gain, lb.	138.5	138.0	121.6[b]	132.2
Average daily gain, lb. per pig	1.69	1.68	1.48	1.61
Average daily feed, lb. per pig	6.73	6.55	6.11	6.14
Feed per pound gain, lb.	3.98	3.89	4.12	3.81
Carcass length, cm.	73.4	73.4	71.3[c]	72.5
Backfat thickness, mm.	40.8	38.9	37.6	38.4
Dressing percentage, %	76.8	75.7	76.1	74.5
Loin area 10th rib, sq. in.	3.27	3.46	3.27	3.24
Trimmed HLS, %	44.7	46.1	46.3	45.8
Trimmed H, %	17.0	17.4	17.6	17.5
Trimmed L, %	12.8	13.4	13.2	13.2
Trimmed S, %	14.8	15.4	15.5	15.2
Trimmed B, %	10.7	10.2	10.4	10.5
Trimmed HLS, kg.	31.10	31.48	29.08	29.78
Trimmed H, kg.	11.85	11.87	11.07	11.35
Trimmed L, kg.	8.92	9.12	8.28	8.57
Trimmed S, kg.	10.33	10.49	9.73	9.84
Trimmed B, kg.	7.51	7.01	6.56	6.80
Ham density	1.056	1.058	1.059	1.060

[a] Implanted in ear.
[b] Difference from lots 1, 2, and 4 statistically significant ($P<0.05$).
[c] Difference from lots 1 and 2 statistically significant ($P<0.05$).

procedures of trial 1 were repeated except that the barrows were somewhat smaller at the time of implanting, around 60 lb. as compared to 110 lb. in trial 1. The total gain of the lot implanted with 30 mg. stilbestrol (lot 3) was significantly less than that of any of the other lots (table 2). This lot also had a significantly shorter carcass length at slaughter. None of the other characteristics studied were significantly different among lots even though treated lots tended to be leaner than the controls.

In trial 3, three groups of barrows were used with a level of 30 mg. stilbestrol in the treated lots. One treated group, lot 2, was implanted at about 130 lb. to approximate the treatment in trial 1. The other treated

group, lot 3, was implanted at about 70 lb. to approximate the treatment of lot 3 in trial 2. The results in table 3 show that the early treated pigs again had a decreased weight gain (approaching the 1% level of significance) and tended to have shorter carcasses even though the latter difference lacked statistical significance. The increases in percentage of lean cuts, ham and loin in lot 3 over the control lot 1 and late implanted

TABLE 3. RESULTS, TRIAL 3 (94 DAYS, 12 BARROWS PER LOT)

Lot number	1	2	3
		Stilbestrol [a]	
Treatment	Controls	30 mg.	30 mg.
Weight at treatment, lb.	—	131.0	73.2
Initial weight, lb.	71.0	73.8	73.2
Total gain, lb.	134.0	133.7	122.7*
Average daily gain, lb. per pig	1.43	1.42	1.31
Average daily feed, lb. per pig	6.47	6.39	5.68
Feed per pound gain, lb.	4.54	4.49	4.35
Carcass length, cm.	73.0	73.9	72.0
Backfat thickness, mm.	37.5	36.7	33.7
Dresssing percentage, %	76.2	75.5	75.6
Loin area 10th rib, sq. in.	3.22	3.31	3.58
Trimmed HLS, %	45.5	45.6	47.8**
Trimmed H, %	17.8	17.8	18.6*
Trimmed L, %	12.4	12.3	13.1**
Trimmed S, %	15.3	15.5	16.1
Trimmed HLS, kg.	32.19	32.50	31.99
Trimmed H, kg.	12.61	12.62	12.45
Trimmed L, kg.	8.75	8.84	8.76
Trimmed S, kg.	10.83	11.05	10.78
Ham density	1.047	1.048	1.051
Belly density	1.005	1.006	1.010

[a] Implanted in ear.
* Differences from lots 1 and 2 statistically significant ($P<0.05$).
** Difference from lots 1 and 2 statistically highly significant ($P<0.01$).

lot 2 were statistically significant in this trial. In all other characteristics measured lot 3 tended to be leaner than the controls and late implants.

In trials 2 and 3, it was found that the maximum weight gain difference between controls and early stilbestrol implants occurred at 43 and 53 days, respectively. At this time these differences were both statistically highly significant. Therefore, trial 4 was run as a replicate of trial 3, but half of the barrows in the control and early implanted groups were slaughtered at 61 days or when the weight increase difference might be expected to be about at maximum. Trial 4 (table 4) is, therefore, divided into two parts, Part A extending from the start when the early implanted group was treated to the time of early slaughter at 61 days. Part B started immediately following the slaughter of these light weight animals. At this

time the late implanted group (lot 2) was treated. Lot 3, the surviving early implants, was reimplanted at the start of Part B with an additional 60 mg. dose of stilbestrol. All animals were slaughtered 49 days following the last treatment. The results of trial 4 are shown in table 4. In this trial there were no significant differences in average daily gain or carcass length between early-slaughtered treated and controls (Part A) or late-slaughtered treated and controls (Part B).

TABLE 4. RESULTS, TRIAL 4 (110 DAYS)

	Part A, 61 days			Part B, 49 days		
Lot number	1	2	3	1	2	3
			Stilbestrol[a]			Stilbestrol[a]
Treatment	Controls		30 mg.	Controls	60 mg.	60 mg.[b]
Number barrows per lot	12	6	10	6	6	5
Weight at treatment, lb.	—	—	60.0	—	126.7	133.5[b]
Initial weight, lb.	65.8	54.0	60.0	134.7	126.7	133.5
Total gain, lb.	75.4	72.7	74.3	74.8	74.3	73.3
Average daily gain, lb. per pig	1.24	1.19	1.22	1.53	1.52	1.50
Average daily feed, lb. per pig	5.15	4.77	4.64	7.32	7.03	6.85
Feed per pound gain, lb.	4.17	4.01	3.80	4.81	4.63	4.56
Number carcasses studied	6		5	6	6	5
Carcass length, cm.	65.4		64.0	73.4	71.4	72.6
Backfat thickness, mm.	32.0		24.7**	37.0	35.0	33.4
Dressing percentage, %	79.5		79.5	77.0	77.1	77.5
Loin area 10th rib, sq. in.	2.85		3.27*	3.42	3.44	3.60
Carcass density	1.051		1.062*	1.035	1.040	1.044
Ham density	1.046		1.058**	1.043	1.044	1.049
Loin density	1.026		1.043*	1.026	1.025	1.027
Shoulder density	1.043		1.054*	1.037	1.042	1.047
Belly density	1.000		1.017**	1.011	1.014	1.017

[a] Implanted in ear.
[b] 30 mg. formerly implanted in ear at 57.6 lbs. in Part A, lot 3.
* Difference from lot 1 statistically significant ($P<0.05$).
** Difference from lot 1 statistically highly significant ($P<0.01$).

In Part A, the early treated barrows had significantly less backfat, a greater eye muscle area of the 10th rib, and greater densities of the entire carcass, ham, loin, shoulder, and belly than controls. At the end of Part B these differences were smaller and lacked statistical significance.

In all trials there was a consistent trend for stilbestrol-treated hogs to be leaner, especially the early treated hogs receiving 30 mg. These differences were statistically significant in some cases, but many were small in magnitude and lacked statistical significance. All four trials were conducted under similar conditions and followed a definite progression of partial replication. The combined data on barrows raised to market weight and implanted with 30 mg. or more stilbestrol and their controls were submitted to analysis of variance, multiple classification, by the method of

fitting constants (Snedecor, 1956). The combined data adjusted by fitting constants is presented in table 5, together with a tabulation of difference in table 6.

When stilbestrol implantation occurred in the light weight barrows, weight increase was reduced about 10%. Daily feed consumption was also less. Although economy of feed utilization appeared greater in implanted

TABLE 5. SUMMARY OF RESULTS, FOUR TRIALS

Lot number		1	2	3
Treatment	Number of experiments	Controls	Stilbestrol	
Total number barrows or experiments	4	34	22	29
Weight at treatment, lb.	–	–	108.0[a]	57.6[b]
			131.0	73.2
Average daily gain, lb. per pig	4	1.54	1.52	1.40**
Average daily feed, lb. per pig	2	7.26	7.08	6.54*
Feed per pound gain, lb.	2	4.66	4.57	4.39
Carcass length, cm.	4	73.3	73.1	71.9*
Backfat thickness, mm.	4	38.6	36.5	35.2**
Loin area 10th rib, sq. in.	4	3.37	3.48	3.58
Trimmed HLS, %	3	45.5	46.0	47.6**
Trimmed H, %	3	17.5	17.6	18.2**
Trimmed L, %	3	12.7	12.7	13.3**
Trimmed S, %	3	15.3	15.7	16.1*
Trimmed HLS, kg.	3	32.05	32.36	31.07
Trimmed H, kg.	3	12.29	12.34	11.88
Trimmed L, kg.	3	8.98	8.99	8.69
Trimmed S, kg.	3	10.78	11.03	10.50
Ham density	3	1.049	1.050	1.053*
Belly density	2	1.008	1.010	1.014**

[a] 30 or 60 mg. implanted in ear.
[b] 30 mg. implanted in ear, with one expt. having 60 mg. additional at 133.5 lbs.
* F value statistically significant ($P<0.05$), see table 6.
** F value statistically highly significant ($P<0.01$), see table 6.

barrows, the differences were not statistically significant. The carcasses of the early implanted barrows were shorter and had less backfat.

Although the area of the eye muscle of the 10th rib of the early implants was not significantly different from control pigs in the combined data, the fact that this muscle area was as great as or greater than that of the significantly larger control animals suggests that the hormone treatment resulted in some increase of muscular development. This suggestion is further substantiated by the finding of a significantly larger eye muscle area in animals killed after early growth and before fattening (trial 4, Part A). The percentage of lean cuts in the early-implanted animals was significantly increased as was the density of the ham and belly.

The barrows implanted with stilbestrol at heavier weights do not show

significant increases over the controls in any of the characteristics studied. In this respect the combined data analysis failed to substantiate the eye muscle and shoulder measurement findings of trial 1. The differences between the late- and early-implanted barrows were significant for weight increase, average daily feed consumption, carcass length, percentages of lean cuts (ham and loin) and ham density. Differences between late and early implanted barrows lacked statistical significance for backfat thickness, percentage of shoulder, and belly density. Implantation at an early age appears to cause a more pronounced effect with respect to a reduction

TABLE 6. OBSERVED AND LEAST SIGNIFICANT DIFFERENCES FROM TABLE 5

(for characteristics with significant differences by analysis of variance)

Item	Differences between groups 1 and 3		Differences between groups 2 and 3	
	Observed	LSD	Observed	LSD
Average daily gain, lb.	—0.14	0.08**	—0.12	0.09**
Average daily feed, lb.	—0.72	0.67**	—0.54	0.47*
Carcass length, cm.	—1.4	1.0*	—1.2	1.1*
Backfat thickness, mm.	—3.4	2.9**		
Trimmed HLS, %	2.1	1.5**	1.6	1.3*
Trimmed H, %	0.7	0.6**	0.6	0.5*
Trimmed L, %	0.6	0.6**	0.6	0.6**
Trimmed S, %	0.8	0.6**		
Ham density	0.004	0.004**	0.003	0.003*
Belly density	0.006	0.006**		

* LSD at 5% level of significance.
** LSD at 1% level of significance.

in rate of gain and the production of a leaner carcass than implantation at heavier weights. The late-implanted barrows show little or no deviation from controls as to weight gain and carcass length but tend to be intermediate in leanness between the controls and early implants in most respects.

The use of estradiol and progesterone (lot 4, trial 2) gave results intermediate between the controls and stilbestrol implanted barrows. Dosage with 7.5 mg. stilbestrol (lot 2, trial 2) was not as effective as 30 mg. in early implanted barrows, and 60 mg. stilbestrol implanted at 130 lb. (lots 2 and 3, trial 4B) was of no more benefit that 30 mg.

Discussion

The effect of treatment on size and congestion of the vulva and teat development has been consistently observed by others (Dinnuson *et al.*, 1951; Pearson *et al.*, 1952; Beeson *et al.*, 1955; Taylor *et al.*, 1955; Sewell *et al.*, 1957). The ovarian response to stilbestrol is unpredictable (Taylor *et al.*, 1955). They may appear hyperemic and enlarged with many small

cysts (Pearson *et al.*, 1952), or they may be smaller than those of untreated gilts (Woehling *et al.*, 1951). Hypertrophy of the seminal vesicles of treated barrows has previously been reported by Woehling *et al.* (1951).

In all trials there appears to be a trend for treated animals (especially 30-mg.-stilbestrol-early implants) to have less backfat and a higher percentage of lean cuts than controls. Increase in eye muscle area in trials 1 and 4A may suggest an increase in relative lean body mass. That these effects are not attributable to lighter carcasses is demonstrated in trial 4A where many differences were significant even though there was no difference in carcass size.

Comparable effects to our observations with stilbestrol have been described following methyl testosterone treatment. Thus Beeson *et al.* (1955) and Perry *et al.* (1956) showed a depression of average daily gain, a decrease in fat, and an increase in lean. It is well known that androgens, such as methyl testosterone, exert a protein anabolic effect (Drill and Saunders, 1956). This similarity of response between estrogens and androgens was best demonstrated in our experiments when animals were treated at an early age and slaughtered at weights of 130 to 140 lb. If treatment was delayed until a later age, towards the end of the early growth period, little or no effect could be shown. The reason for age differences in response is not obvious. At least two possibilities suggest themselves: (1) when large fat deposits are present, estrogen may be rapidly removed and retained by these fat stores thereby reducing the effective systemic level; (2) estrogens by affecting protein metabolism may be most effective during early growth when rate of protein synthesis is high. At later stages when weight gains are largely the result of fat deposition and rate of protein synthesis is reduced, the effects of estrogen may not be as clear-cut.

Before the effects of estrogen administration in swine on protein metabolism can be clearly established, further investigations on nitrogen retention are needed.

Summary

Four trials have been completed using 136 growing-fattening barrows and gilts to study the effects of subcutaneous stilbestrol implants in the ear. Within 2 days following treatment gilts showed typical symptoms of edematous, hyperemic vulvae. Both barrows and gilts had enlarged teats and increased sexual activity. At slaughter the barrows had hypertrophied seminal vesicles, and gilts had either atrophied or enlarged, cystic ovaries.

Implantation of 30 mg. stilbestrol in lightweight feeder pigs (58–73 lb.) resulted in reduced gains during the feeding-fattening period. On the other hand, the same treatment in heavyweight feeders (108–131 lb.) had no effect on gains. Coincident with reduced gain in the early treated pigs was a reduced feed intake and a trend towards greater feed utilization.

The various trials gave evidence of leaner carcasses in the early-treated pigs, and analysis of variance (multiple classification) of combined data

by the method of fitting constants on barrows implanted with 30 mg. or more of stilbestrol indicated that the early implants had shorter carcasses, less backfat, a greater percentage of lean cuts, and greater densities of untrimmed hams and bellies than controls. Leanness of the late-treated pigs was intermediate between the controls and early implanted ones. Largest weight differences between early implants and controls occurred at about 43–53 days following treatment, and pigs slaughtered at this time (approximately 135 lb.) showed maximal differences in backfat thickness, loin area at the 10th rib and densities of entire carcass, untrimmed belly, and the various untrimmed lean cuts. A possible protein anabolic effect of stilbestrol in pigs during the rapid protein storage phase of growth similar to that of methyl testosterone is suggested.

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SOME EFFECTS OF FEEDING ANIMAL FAT AND N,N'-DIPHENYL-P-PHENYLENEDIAMINE TO SWINE [1]

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THE use of animal fats in the rations of swine has met with varied results. Kropf *et al.* (1954) reported that feeding a ration containing 10% of waste beef fat to pigs from 120 to 180 lb. had no effect on weight gains. However, they found that when weanling pigs were fed the 10% fat ration until they reached about 180 lb., they grew faster than the control pigs receiving no added fat. Barrick *et al.* (1953) also reported increased weight gains in pigs fed a 10% level of beef fat.

Heitman (1956) reported increased weight gains of swine fed a ration supplemented with either 5 or 10% of stabilized tallow. On the other hand, a ration supplemented with 10% of stabilized lard did not affect weight gains. Other workers (Perry *et al.*, 1953) have also reported that stabilized lard is without effect on weight gains when fed at levels up to 10% of the ration.

Numerous investigations have indicated that the type of fat fed to swine can have a marked influence on the characteristics of the body fat deposited. Baird (1955) reported that hogs fed rations containing 5% of stabilized tallow deposited harder depot fat than hogs fed no tallow. Furthermore, Garton and Duncan (1954) concluded that lard and cod-liver oil fed to pigs were absorbed essentially unchanged and deposited in the depots and that the fate of these depot fats is largely affected by the amount of antioxidants present.

The objectives of the experiment reported herein were to determine: (1) the effects on rate of gain, feed efficiency, and certain carcass characteristics when a 10% level of inedible animal fat is added to the rations of growing and fattening swine; (2) the most efficient period, based on the above criteria, for adding fat to swine rations; (3) the influence of a dietary antioxidant N,N'-diphenyl-para-phenylenediamine (DPPD) on the keeping qualities of pork.

Experimental

Twenty-four weanling Palouse pigs averaging approximately 61 lb. each, were used in this experiment. The pigs consisted of 16 barrows and 8 gilts and were randomly divided by sex into four groups of six animals. The animals were individually self-fed the experimental rations shown in table 1.

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The rations were equated for protein and were compounded in accordance with the nutrient requirements for swine recommended by the National Research Council. Fat was substituted for barley at a level of 10% in half of the rations.

The animals were treated in the following manner throughout their growing and fattening period: Group I (control) received no added dietary fat during the entire experiment; Group II was fed a ration containing 10% added fat until 120 lb. body weight and no supplemental fat thereafter; Group III received no added fat to 120 lb. and then received a ration containing 10% fat until slaughter. Group IV was fed a ration containing 10% of added fat throughout the entire experimental period. DPPD was incorporated into the rations at a 0.1% level so that one half the animals in each group received it. When a weight of approximately 120 lb. was

TABLE 1. PERCENT COMPOSITION OF EXPERIMENTAL RATIONS

	Rations fed to 120 lb.				Rations fed 120–195 lb.			
Ingredient	1	1a	2	2a	3	3a	4	4a
Barley	71.2	71.2	59.0	58.9	84.0	83.9	71.6	71.5
Meat scraps (55%)	11.4	11.4	12.5	12.5	5.0	5.0	6.2	6.2
Soybean oil meal	11.4	11.4	12.5	12.5	5.0	5.0	6.2	6.2
Inedible fat	....	....	10.0	10.0	....	....	10.0	10.0
Deh. alfalfa	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Salt	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DPPD	....	0.1	....	0.1	....	0.1	....	0.1

reached, a sample of body fat was taken from a portion of the clearplate, by the biopsy technique of Erwin *et al.* (1956). The fat samples were frozen at —12° F. until the refractive index of each was determined with an Abbe refractometer. Each animal was slaughtered when it reached approximately 195 lb. At the time of slaughter, another sample of fat was taken and treated in the same manner.

Also, at slaughter, a portion of the clear-plate was removed and stored in an open air cooler at 36° F. for 21 days. At the end of the 21-day storage period, the peroxide and free fatty acids were determined on each sample according to the method of Rockwood *et al.* (1947). The following carcass measurements were determined: backfat thickness, dressing percentage, and yield of primal cuts.

All of the data from this experiment were subjected to analysis of variance (Snedecor, 1946).

Results and Discussion

The effects of feeding animal fat in the rations are shown in tables 2 and 3.

The incorporation of animal fat into rations of pigs up to 120 lb. body weight significantly increased the growth rate ($P<.01$) over pigs fed no added fat (table 3). A statistically significant ($P<.05$) increase in

TABLE 2. EFFECTS OF DIETARY ANIMAL FAT ON GROWTH, FEED UTILIZATION AND CERTAIN CARCASS CHARACTERISTICS IN SWINE

Item	Group I Control	Group II Added fat to 120 lb.	Group III Added fat 120–195 lb.	Group IV Added fat to 195 lb.
Number of animals	6	6	6	6
Av. initial wt., lb.	58.3	60.8	62.5	62.5
Av. daily gain, lb.				
61–120 lb.	1.46	1.75	1.65	1.92
120–195 lb.	1.56	1.67	1.99	1.68
61–195 lb.	1.51	1.72	1.77	1.68
Feed per cwt. gain, lb.				
61–120 lb.	349	300	333	294
120–195 lb.	446	414	412	425
61–195 lb.	408	359	353	346
Carcass data				
Av. backfat, inches	1.48	1.75	1.62	1.65
Dressing per cent	72.2	71.7	70.9	72.1
Yield primal cut, % [a]	67.5	67.1	68.1	67.8
Refractive index				
120 lb.	1.4584	1.4591	1.4592	1.4594
195 lb.	1.4594	1.4601	1.4600	1.4601
Free fatty acids, %	.737	.733	.703	.682
Peroxide value	16.291	15.013	16.473	15.461

[a] Primal cuts were considered to be hams, bellies, loin, picnics and Boston butts.

rate or gain also resulted from supplementing a 10% level of fat from 120 lb. to slaughter. These results agree in general with the results reported by several other workers (Barrick *et al.* 1953; Kropf *et al.*, 1954; Heitman, 1956) while they disagree with the experiment reported by Perry *et al.* (1953). In the latter work, however, stabilized lard was fed. The total number of days necessary to reach slaughter weight was significantly ($P>.05$) reduced by including added animal fat in the ration.

The efficiency of feed use was increased significantly ($P<.05$) in the

TABLE 3. EFFECT OF DIETARY FAT ON GROWTH RATE AND EFFICIENCY OF FEED UTILIZATION

Item	No. animals per treatment	No fat	10% fat
Rate of gain, lb.			
61–120	12	1.55	1.83**
120–195 lb.	12	1.61	1.84*
61–195 lb.	6	1.51	1.68
Feed per cwt. gain, lb.			
61–120 lb.	12	341	297*
120–195 lb.	12	430	418
61–195 lb.	6	408	356*

* $P<.05$; ** $P<.01$.

pigs receiving rations containing 10% added fat up to 120 lb. body weight (table 3). During the period from 120 lb. to slaughter weight, however, the inclusion of fat in the ration did not significantly increase the feed efficiency. The increase in feed efficiency that resulted from supplemental dietary fat throughout the total growing and fattening period (61–195 lb.) was significant ($P<.05$). This was expected since fat was substituted for an equal weight of grain in the rations in which it was fed. Similar results on the overall effects of feeding fat to swine have been reported by several other workers (Perry *et al.*, 1953; Baird, 1955; Heitman, 1956). In the latter studies, feed efficiency was apparently increased, although group feeding of the animals did not allow statistical analysis.

TABLE 4. EFFECT OF DPPD ON CERTAIN CARCASS CHARACTERISTICS

Item	Control	0.1% DPPD
Number of animals	12	12
Av. backfat, inches	1.58	1.68
Dressing percent	71.83	71.68
Yield primal cuts, %	67.41	67.88
Refractive index		
120 lb.	1.4597	1.4601
195 lb.	1.4590	1.4591
Free fatty acids, %	.763	.665
Peroxide value	1.947	1.217**

** $P<.01$.

Under the conditions of this experiment, it appears that 10% added inedible animal fat fed in rations to swine up to a body weight of 120 lb. gave a greater response than when it was fed to swine from 120 to 195 lb. body weight. When comparing the effects during the complete growing and fattening period, however, there were no significant differences between feeding fat during the first period (61–120 lb.) and the last period (120–195 lb.), or feeding fat throughout the entire experiment (table 2). All three groups receiving fat sometime during the experiment performed markedly better than the control group, on the basis of rate of gain, number of days to reach slaughter weight, and feed efficiency.

None of the carcass measurements taken was significantly affected by feeding 10% animal fat in the ration. The thickness of the backfat appeared to be increased somewhat by the incorporation of fat in the ration; but the differences were not statistically significant. Kropf *et al.* (1954) and Baird (1955) have reported that dietary fat had no effect on thickness of backfat. Barrick *et al.* (1953) found increased backfat thickness in swine fed 10% fat rations. Heitman (1956) reported the increased backfat thickness of tallow-fed hogs to be no greater than to be expected considering their greater body weight.

Feeding a 0.1% level of DPPD in the rations had no effect on rate of gain, days required until slaughter, or feed efficiency. Data on the effects of feeding DPPD on the carcass are in table 4.

The peroxide value was decreased significantly ($P<.01$) in fat samples taken from hogs fed DPPD and stored 21 days at 36° F. This result suggests the dietary DPPD may protect the natural antioxidants present in the tissue. These results indicate that the pork from hogs fed DPPD had better keeping qualities, as measured by peroxide value, than the controls.

No fat-antioxidant interaction was found in this experiment.

Summary

Twenty-four Palouse pigs were divided into four groups of 6 pigs and individually self-fed the experimental rations. The variables were a 10% level of added inedible animal fat and a 0.1% level of N,N'diphenyl-para-phenylenediamine (DPPD). The pigs were treated as follows: Group I received no added dietary fat during the entire experimental period. Group II was fed a ration which contained 10% added fat until 120 lb. body weight and no added fat thereafter. Group III received no added fat to 120 lb. and then a 10% added fat ration until slaughter (195 lb.). Group IV was fed a ration containing a 10% level of added fat throughout the entire experimental period. DPPD was fed at a 0.1% level to half the animals in each group.

Added animal fat significantly increased the rate of gain when fed to pigs to a weight of 120 lb. ($P<.01$) and when fed between weights of 120 to 195 lb. ($P<.05$). The number of days required to reach a weight of 120 lb. was significantly less for the groups receiving fat in the ration ($P<.05$). Feed efficiency was also significantly improved by feeding added fat until pigs reached 120 lb. body weight ($P<.05$). Added fat did not significantly improve feed efficiency when fed to hogs only between 120 and 195 lbs. body weight.

The carcass measurements taken were not affected by feeding a 10% added level of animal fat in the rations.

Feeding DPPD in the swine rations did not significantly influence the rate of gain, number of days required until slaughter, or feed efficiency. The dietary antioxidant did, however, significantly ($P<.01$) decrease the peroxide value of fat samples taken at slaughter and stored for 21 days at 36° F.

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FEEDING OF CRUDE AND MODIFIED MENHADEN OILS IN RATIONS FOR SWINE [1, 2, 3]

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RECENT experience in the feeding of California sardine oil (Anglemier, 1957) has suggested that a dietary level of 5.5% might be fed to growing swine without detriment to their growth rate or efficiency of feed conversion. Certain objectionable characteristics in flavor, odor and color of the carcass fat would, however, have to be overcome before this practice could be commercially acceptable.

Menhaden oil is more readily available at present than sardine oil, and has the additional advantage that it is less highly unsaturated than sardine oil (Armstrong, 1924; Brocklesby, 1933). Certain information is available in the literature regarding feeding of menhaden oil to swine. Brown (1931) reported that feeding a ration containing 14% menhaden oil to swine for five weeks prior to slaughter resulted in a marked yellow color in the carcasses. Further, Vestal *et al.* (1945) found that 0.5 or 1.0% menhaden oil added to swine rations containing 10% menhaden fish meal resulted in a fishy flavor in cooked pork from all animals fed. Treatment of fish oil to prevent or reduce degradation during storage offers some possibility of overcoming undesirable carcass effects, while maintaining satisfactory growth. In this connection Kaneda and Arai (1953) reported superior gains in rats fed polymerized dogfish liver oil than in those fed similar amounts of the crude oil. Depressed rates of growth and feed utilization in rats fed polymerized oils were reported, however, by Lassen *et al.* (1949) and Aaes-Jorgensen (1954).

The following study was designed to investigate the effects of additions of 5% crude or modified menhaden oils to swine rations upon growth, feed use and carcass quality of the animals.

Material and Methods

The oil products used in this experiment included: crude menhaden oil, alkali refined and bleached oil and polymerized (kettle bodied, Admiral XY) oil. All were commercially available and were obtained from the same

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Sixteen weaned Berkshire pigs averaging 52 lb. weight were placed in individual feeding pens and four each were allotted ration treatments as follows: 1. Basal ration+5% crude menhaden oil; 2 Basal ration+5% alkali refined and bleached menhaden oil; 3. Basal ration+5% polymerized menhaden oil; 4. Control, Basal ration (Anglemier, 1957).

All rations were pelleted and stored in multi-wall paper sacks in the feeding barn. Proximate analyses of the rations at the start of the trial revealed crude protein contents of 15.6, 15.5, 15.3 and 16.1%, and ether extract contents of 10.2, 10.6, 9.8 and 4.8% for groups 1–4, respectively. Qualitative tests were carried out on the three oils at the start of the trial with results shown in table 1.

TABLE 1. QUALITATIVE CHARACTERISTICS OF TEST OILS

Item	Crude oil	Alkali washed	Polymerized
Iodine number [c] gm. I/100 gm. oil	163	169	103
TBA value [a] OD/0.25 gm. oil	0.254	0.272	0.010
Peroxide value [b] μeq./gm. oil	38.9	54.8	13.1

See [a] Yu and Sinnhuber (1955); [b] Hartman (1954); [c] A.O.A.C. (1955).

The animals were slaughtered at approximately 190 lb. weight, and the right kidney, a portion of the liver and of the back fat were obtained for qualitative and quantitative fat determination. In addition, one Boston butt roast was obtained from each carcass for cooking test.

Results and Discussion

Effects of the various rations on rate of gain and efficiency of feed conversion of the animals during the trial are shown in table 2. Lot 3, which received the polymerized oil ration, required more feed per pound gained than did the other groups. This difference was statistically significant when tested by analysis of variance ($P<0.05$). Lots 1 and 2, fed crude and alkali washed menhaden oil, performed in a superior way to lots 3 and 4, fed polymerized oil and the control ration respectively. Analysis of variance showed these differences and that between lots 3 and 4 to be significant ($P<0.05$). The poorer growth of the animals fed polymerized menhaden oil was influenced by lower palatability of this product, and lower feed intake in lot 3 than in the others. Lassen (1949) has reported that polymerized oil has a lower coefficient of digestibility than unpolymerized oil, which may help explain the lowered efficiency of feed utilization. On the other hand, polymerization of the oil greatly reduced the objectionable characteristics imparted to the carcasses as observed in previous oil feeding experiments (Anglemier, 1957). Carcasses of lot 3 pigs were indistinguishable from those of the controls on the basis of

fat coloration. Results of organoleptic tests on cooked Boston butt shoulder roast are listed in table 3.

Polymerized oil feeding apparently resulted in improved flavor and odor of cooked cuts over other oils tested. All roasts from lots 1 and 2 produced an undesirable, fishy odor while cooking, but only two roasts from lot 3 had any objectionable odor. Tenderness and juiciness were highly satisfactory in roasts from all treatments.

TABLE 2. WEIGHT GAINS AND FEED EFFICIENCY OF PIGS FED DIETS CONTAINING 5% CRUDE OR TREATED MENHADEN OIL

Lot number	Average daily gain	Feed per pound gain	Days to slaughter
	lb.	lb.	
1	1.55	3.18	92
(Crude oil)	1.57	3.39	92
	1.59	3.17	92
	1.77	3.16	78
Average	1.62	3.23	88.5
2	1.59	3.50	92
(Alkali washed oil)	1.64	3.11	85
	1.62	3.10	85
	1.60	3.20	92
Average	1.61	3.23	88.5
3	1.36	3.80	99
(Polymerized oil)	1.33	3.81	113
	1.14	4.27	113
	1.19	3.77	133
Average	1.26	3.91	109.5
4	1.46	3.40	99
(Control)	1.48	3.46	92
	1.35	3.47	99
	1.58	3.25	92
Average	1.47	3.40	95.5

Thickness of back fat on the chilled carcasses showed little difference among treatment groups. Average thickness over three points (opposite 1st and 10th rib and last lumbar vertebra) was 1.4, 1.3, 1.3 and 1.3 inches, respectively for lots 1–4. Length and weight of the kidneys from pigs fed polymerized oil was greater than for those of pigs on other treatments. Kidney lengths averaged 13.1, 12.8, 14.0 and 12.5 cm., and weights averaged 134.4, 140.7, 156.2 and 131.0 gm. respectively in lots 1–4.

Ether extraction of kidney and liver tissue did not reveal differences

in total fat content, however, Iodine number tests run by the Hanus method (A.O.A.C., 1955) showed significant differences in fat hardness. Iodine numbers (gm. I/100 gm. fat) for lots 1–4 were 71.6, 72.8, 59.5 and 57.7, respectively. Polymerization of the oil fed apparently resulted in decreased unsaturation of depot fat. These various observations suggest that if methods of polymerization of fish oils could be modified so as to enhance their nutritional qualities, such oils might be fed at levels up to 5% of swine diets without detriment to the quality of carcasses produced.

TABLE 3. AVERAGE SCORES[a] FOR PORK ROASTS FROM ANIMALS FED CRUDE AND TREATED MENHADEN OILS

Characteristic judged	Crude Menhaden	Alkali refined	Kettle body polymerized	Control
Number of judges	8	8	8	8
Total no. of scores	28	30	28	28
Odor	3.5	3.4	5.0	4.9
Flavor of fat	2.8	2.5	5.2	3.4
Flavor of lean	3.8	3.2	5.5	5.4
Tenderness	6.1	5.5	5.9	5.8
Juiciness	5.5	5.5	5.5	5.3
Total	21.7	20.1	27.1	24.8
Average	4.3	4.0	5.4	5.0

[a] A score of 5 was considered representative of "normal" pork.

Summary

Crude menhaden oil, and similar oils modified by alkali washing and bleaching and by polymerization ("kettle bodied") were fed at a 5% level to groups of 4 each, growing Berkshire pigs. Four additional pigs were fed a similar basal ration without fish oil.

Superior growth performances, as compared with the control animals was obtained in the groups fed crude and alkali washed menhaden oils. Inferior growth performance was obtained in the group fed polymerized menhaden oil.

No differences were apparent in the thickness of back fat, or in the fat contents of livers and kidneys among pigs fed the four rations.

Fat hardness, as measured by Iodine number, was superior in the groups fed the polymerized oil ration and the basal ration.

Quality of the meat, as measured by cooking tests, was superior in the groups fed the polymerized oil ration and the basal ration. A fishy odor and taste was noticeable in the meat of animals fed the crude and alkali washed menhaden oils.

Larger kidneys were observed in the group fed the polymerized oil. The significance of this finding is not apparent.

Polymerized menhaden oil appears to offer possibilities in swine ration-

ing as far as carcass quality of the animals is concerned. Such possibilities would be enhanced if polymerization could be effected in such a way as to improve the nutritional qualities of the oil.

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FEEDING OF VARIOUS LEVELS OF PILCHARD (CALIFORNIA SARDINE) OIL TO SWINE [1, 2, 3]

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FISH oils are presently available in quatities and at prices permitting their possible use as energy sources in livestock feeds. Encouragement for such use is provided by recent successes in feeding fats and tallow from terrestial species (Schweigert, 1954; Heitman, 1955) and by the observations of Deuel (1955) that diets containing 20–40% fat supported superior growth in laboratory animals. Most farm animal diets contain less than half this much fat—a situation accentuated by continued improvement in fat extraction from oil-bearing seeds and other common diet ingredients. British workers (Garton *et al.*, 1952) reported normal growth and health in a pig fed from weaning on a diet containing 50% crude whale oil. Conversely, Gorham *et al.* (1951) encountered subnormal growth and undesirable fat characteristics in pigs fed a diet containing 85% fresh, frozen fish scrap (which contributed 5.77% fish oil to the diet). Frazer *et al.* (1934) also noted fishy tasting meat, in pigs fed one-half to one ounce of cod liver or pilchard oil daily, however discontinuation of oil feeding 30 days before slaughter overcame this objection.

A satisfactory energy supplement for farm animal diets must be palatable enough to maintain a desirable level of feed intake, and with other diet constituents, support optimum growth in the animals fed. Moreover, it should supply nutrients economically in comparison to other feedstuffs and must result in formation of a high-quality, saleable product. The investigation described herein was designed to test the effects of various levels of a commercially available fish oil in swine rations according to these criteria.

Materials and Methods

Sixteen weaned Berkshire pigs were placed in individual feeding pens and four each were allotted to ration treatments as follows: 1. Control—Basal Ration,[4] 2. Experimental—Basal Ration with 2.75% California sardine *(Sardinops caerulea)* oil replacing a like amount of barley, 3. Experimental—Basal Ration with 5.5% sardine oil replacing a like amount

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[3] Grateful acknowledgement is made to T. K. Johnson for assistance in selection and care of experimental animals; to Andrea O. Mackey for supervision of organoleptic tests and to M. E. Stansby, Fisheries Technological Laboratory, Seattle, for advice throughout the trial.

[4] The Basal Ration (O.S.C. No. 20) was one used successfully in previous experiments. Its composition is shown in table 1.

of barley, 4. Experimental—Basal Ration with 8.25% sardine oil replacing a like amount of barley.

All rations were prepared in pelleted form in amounts sufficient for the entire feeding period, and were stored in multi-walled paper sacks at barn temperature. Animals were fed twice daily on a simulated *ad lib.* basis and given free acces to water. Body weights of animals were taken at weekly intervals. The trial was designed to be run until the animals passed the weight of 190 lb.

TABLE 1. BASAL RATION USED IN FISH OIL FEEDING EXPERIMENTS

Ingredients	lb.
Ground barley	1100
Ground oats	555
Alfalfa meal	150
Soybean oil meal	100
Tankage, 60% digester	75
Oyster shell flour	10
Iodized salt	10
Total	2000

Crude protein contents of rations fed lots 1–4 were 13.36, 13.00, 13.02 and 12.36%, respectively. Ether extract contents, in the same order, were 4.28, 6.76, 10.29 and 12.29%. Peroxide value determinations were run at the start of the test, to indicate condition of the oil. Resulting values for oils extracted from rations fed lots 2 to 4 respectively were 62.6, 72.2 and 102 micro equivalents per gram (Sinnhuber, 1955).

Results and Discussion

The weight gains and efficiency of feed conversion of the pigs on the various treatments are listed in table 2.

Growth rate and feed efficiency of the pigs receiving the two lower levels of fish oils compared favorably with that of pigs fed the control ration, suggesting that, nutritionally speaking, similar fish oils may be fed at these levels to swine without detriment to growth performance. Only one of the four animals consistently ate the highest level fish oil ration, however, and made gains comparable to the controls. After four weeks on test the other three pigs in lot 4 consistently refused some of their daily ration. Their rates of gain declined, and after 9 weeks on test, when most of the animals on other treatments had gone to slaughter, they were barely maintaining their weight. Accordingly they were switched from the high fish oil diet to the control diet until the designated 190 lb. weight was reached. Recovery of these pigs to normal appetite was slow, hence weight gains continued at a reduced rate. This poor response of the lot 4 animals

appeared due to low feed intake, rather than to lowered efficiency of feed use.

Physical measurements of carcasses of the animals did not reveal significant differences in back fat thickness or dressing percentage attributable to the fish oil in the diets. Average back fat thickness computed from three measurements (taken opposite 1st and 10th rib, and last lumbar vertebra) was 1.58, 1.48, 1.17 and 1.07 inches for lots 1–4 respectively. There was,

TABLE 2. WEIGHT GAINS AND FEED EFFICIENCY OF PIGS ON DIETS CONTAINING VARIOUS LEVELS OF CALIFORNIA SARDINE OIL

Lot number	Level of oil added	Av. daily gain	Feed per pound gain	Days to slaughter
	%	lb.	lb.	
1	0	1.94	3.57	63
		1.86	3.71	63
		1.92	3.49	63
		1.51	3.25	84
		Group Av. 1.78	3.50	68
2	2.75	1.86	3.49	63
		1.92	3.49	63
		1.81	3.67	63
		1.80	3.66	70
		Group Av. 1.85	3.58	65
3	5.50	1.57	3.92	98
		1.94	3.08	63
		1.87	3.31	63
		1.74	2.97	70
		Group Av. 1.64	3.31	73
4 [a]	8.25	1.67	3.10	63
		0.77	5.45	155
		1.13	4.15	105
		0.76	5.59	155
		Group Av. 1.08	4.57	119

[a] Three animals in lot 4 refused to eat this ration consistently and after 9 weeks were changed to the control diet on which they were maintained to the end of the test.

in fact, a trend toward lesser back fat thickness in carcasses of the pigs fed the oil-containing rations.

Iodine number determination on samples of back fat yielded the following averages for lots 1–3, respectively: 56.1 ± 1.52, 68.7 ± 1.05 and 67.5 ± 1.38. In lot 4, two animals slaughtered first (63 and 105 days) had back fat averaging an Iodine number of 69.3, while two others slaughtered after 13 weeks on the non-oil containing diet averaged 58.7. Ether extraction was

performed on liver samples from all animals. Lots 1, 2 and 3 showed average liver ether extract contents of 12.1, 14.6 and 12.5% respectively. The comparative value for the two pigs slaughtered last in lot 4 (after 155 days) was 7.7%—a further indication of the retarded growth of the animals.

While feeding of fish oils at the levels noted was apparently not detrimental in terms of quantity of carcass fat, the quality of the depot fat was definitely undesirable in animals fed the two higher levels, lots 3 and 4. Fat from these latter animals was highly pigmented, giving the lard a yellowish-grey appearance. Further, this fat was soft and greasy causing chilled cuts from these animals to appear flabby and not hold their shape like those of the controls.

Organoleptic evaluation of carcass quality was made by a taste panel on Boston butt shoulder roasts prepared under uniform cooking conditions. Objection was shown to cuts from animals fed all three levels of fish oil and flavor of the lean meat was evaluated at 5.8, 3.7, 1.1 and 1.2 for lots 1–4 respectively (where a score of 5.0 represented "average normal" pork). Flavor of fat was scored 4.9, 2.7, 1.2 and 1.4 for lots 1–4; however tenderness and juiciness scores were as high for the fish oil fed pigs as for the controls. A pronounced fishy odor was noticeable on cooking of roasts from all oil fed groups. Purchase of all carcasses in the fish oil fed groups was refused by the packing plant which handled the animals. The undesirable color and odor were not remedied by feeding a non-fish oil containing ration for 13 weeks, although Iodine number determination indicated hardening of the fat by this procedure.

Summary

A trial involving 16 growing pigs fed rations containing 0, 2.75, 5.5 and 8.25% California sardine oil, has been completed.

At 0, 2.75 and 5.5% levels of oil addition growth performance and feed efficiency were satisfactory and essentially equivalent.

At the 8.25% level of oil addition, the animals failed to eat and to gain satisfactorily after 4 weeks on test. When switched to a non-fish oil containing ration after 9 weeks on test, their recovery to normal feed intake and weight gains was slow.

Although total quantitative fat deposition was not markedly different, the quality of depot fat in terms of color, odor and hardness was lowered when sardine oil was fed. Such lowering of quality was most marked at the 5.5 and 8.25% oil levels. These fat characteristics made the meat cuts from pigs thus fed unpalatable and unacceptable from a market standpoint.

Feeding of a non-fish oil containing ration for as long as 13 weeks subsequent to the feeding of the highest level of fish oil was ineffective in

overcoming objections to the odor and flavor, although it increased the hardness of the fat.

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THE EFFECT OF METHOD OF FEEDING UPON THE SUSCEPTIBILITY OF THE PIG TO PARAKERATOSIS [1]

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NUTRITIONAL relationships of calcium and zinc to parakeratosis of swine (Kernkamp and Ferrin, 1953) have been established (Tucker and Salmon, 1955; Lewis *et al.*, 1956; Luecke *et al.*, 1956; Stevenson and Earle, 1956; Lewis *et al.*, 1957; and Luecke *et al.*, 1957). In all these studies the rations were *ad libitum*-fed, dry (self-fed). Observations made in attempting to produce this skin disease experimentally have indicated that the manner in which a ration is fed may also be important. Moreover, Thomas and Eden (1954) reported that a swine dermatitis occuring in England was cured or prevented by wetting the ration prior to feeding. Under the experimental conditions at Wisconsin, it has been possible to produce at will severe parakeratosis in growing pigs by self-feeding a natural ration with a slightly elevated calcium content (0.8—1.4%). This condition has been prevented and cured by supplementing the ration with 100 ppm of zinc (Lewis *et al.*, 1956; Lewis *et al.*, 1957). Experiments were therefore designed to determine the effects of various methods of feeding high calcium rations, both with and without supplemental zinc, on the development of parakeratosis in growing swine. The results of these experiments are reported in this paper.

Further studies on the possible mode of action of calcium in aggravating parakeratosis have also been made. Previous reports (Lewis *et al.*, 1957) have shown that the concentrations of zinc in certain body organs of pigs are decreased by feeding high amounts of calcium suggesting that perhaps calcium was rendering zinc unavailable for absorption from the digestive tract. The results of some *in vitro* experiments are reported which demonstrate that zinc is readily removed from solution during the precipitation of calcium phosphate compounds.

Experimental

Two feeding experiments are reported (I and II). In each case thrifty, weanling pigs were used with five or six pigs per lot. The basal rations used in each of the trials are shown in table 1.

The feeding methods used in experiment I were *ad libitum*-feeding, dry (self-feeding) and hand-feeding, wet. During the first 11 weeks of this comparison the hand, wet-fed pigs received the ration twice a day

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in the wet form and in more than ample amounts. Thereafter for eight weeks, precautions were taken to feed the wet-feed pigs only twice a day amounts which they could consume in 30 minutes.

Experiment II was undertaken to determine whether the decreased susceptibility of the pig to parakeratosis was the result of limited hand-feeding, of wetting the feed or of a combination of these. The feeding methods compared were as follows: *ad libitum*-feeding, dry or self- feeding (Lot 1), *ad libitum*-feeding, wet (Lot 2), hand-feeding, dry (Lot 3), hand-feeding, wet (Lot 4), *ad libitum*-feeding, dry + 100 ppm of zinc

TABLE 1. COMPOSITION OF EXPERIMENTAL RATIONS

Ingredient	Ration [a]	
	Experiment I	Experiment II
	%	%
Corn	82.50	80.75
Soybean oil meal	11.00	14.00
Meat scraps	3.00	3.00
Steamed bone meal	2.00	0.75
Limestone	1.00	1.00
Salt	0.50	0.50
Calcium content, % [b, c]	1.56	1.14
Zinc content, ppm [b]	33	22

[a] Irradiated yeast added to supply 90 I.U. of vitamin D per pound of ration.
[b] Dry weight basis. (These figures on the air dry basis are respectively 1.38 and 1.04% calcium and 30 and 20 ppm zinc).
[c] Phosphorus content by calculation from the same ration fed in other experiments on the air dry basis was: Experiment I—0.72% and Experiment II—0.56%.

(as zinc oxide) in the ration (Lot 5) and hand-feeding, wet + 100 ppm of zinc (as zinc oxide) in the ration (Lot 6). *Ad libitum,* wet-fed pigs were supplied the wet feed in more than adequate amounts so that there was feed available to the pigs at all times. The feed was thoroughly wet just prior to feeding and the feed troughs were cleaned each day. Wooden feed troughs were used. Hand-fed pigs were allowed to eat twice a day (at approximately 8:30 A.M. and 3:30 P.M. for a period of 1 hour at each feeding.

The pigs were weighed biweekly and given skin ratings of 0 to 5 (Lewis *et al.*, 1956).

Experiment II was discontinued at the end of 12 weeks, and the pigs in lots 1 and 4 were killed and liver samples were taken for zinc analysis. The zinc supplemented pigs (Lots 5 and 6) were continued on the same treatments and were killed after 20 weeks at which time liver samples were taken for zinc analysis.

The *in vitro* binding of zinc by the precipitation of calcium phosphates was studied as follows: Solutions, in which the desired amounts of $CaCl_2$, H_3PO_4 and $ZnCl_2$ were combined, were diluted to approximately 30 ml.

with "zinc-free" water and adjusted to the desired pH with redistilled NH_4OH and HCl and diluted with water to approximately 49 ml. After thorough mixing, the solutions were allowed to stand at least 1 hour and the pH was again determined. If the pH had changed slightly, it was readjusted and the solutions were diluted to 50 ml. After centrifugation the supernatant was analyzed for zinc.

Zinc determinations were made essentially by the method of Vallee and Gibson (1948) and Hoch and Vallee (1949) and calcium determinations were made by accepted methods of AOAC (1950). The data were analyzed statistically for differences by a multiple range test method (Kramer, 1956).

TABLE 2. THE EFFECT OF HAND-FEEDING, WET ON THE AVERAGE DAILY GAIN, DEATH RATE AND SKIN CONDITION OF PIGS IN EXPERIMENT I

Item	Treatment	
	Lot 1 *Ad libitum*-fed, dry	Lot 2 Hand-fed, wet
No. of pigs in lot	6	5
No. of pigs dead [a]	1	0
Av. initial wt. (lb.)	41	41
Av. daily gain (lb.)		
First 11 weeks	0.21	0.42 [b]
Last 8 weeks [c]	0.32	0.83 [c, d]
Av. skin rating [e]		
At 11 weeks	3.8 (5/5) [f]	0.4 (2/5)
At 19 weeks	4.4 (5/5)	0.6 (3/5)

[a] From parakeratosis.
[b] No significant difference between lot 1 and 2.
[c] See text for difference in feeding during last 8 weeks.
[d] Significantly different from lot 1 ($P<0.01$).
[e] According to the method described by Lewis *et al.* (1956).
[f] Figures in parenthesis are number of pigs with definite symptoms of parakeratosis over the total number of pigs in the lot.

Results

Experiment I. Table 2 shows the effect of hand-feeding, wet and of *ad libitum*-feeding, dry (self-feeding) on the average daily gain, death rate and the skin rating of the pigs over a 19-week period. During the first 11 weeks, pigs that were hand, wet-fed (all they would eat), gained an average of 0.42 lb. per day compared to 0.21 lb. per day for the *ad libitum,* dry-fed (self-fed) pigs. When precautions were taken to feed the hand, wet-fed pigs only amounts that they could consume in 30 minutes, gains were immediately increased and averaged 0.83 lb. per day for the next 8 weeks. During this same period the average daily

gain of the *ad libitum,* dry-fed pigs increased from 0.21 to 0.32 lb. per day. Therefore it appeared that hand-feeding, wet showed the best protection from parakeratosis when the feed was supplied only in amounts that the pig consumed in a short time after feeding.

There was one death due to parakeratosis in the *ad libitum,* dry-fed pigs and no deaths due to parakeratosis in the hand, wet-fed pigs. From the skin ratings it is evident that hand, wet-feeding greatly decreased the incidence and severity of parakeratosis but did not completely prevent the appearance of the disease.

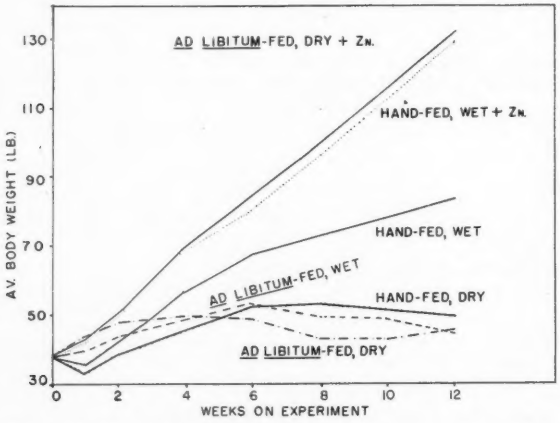

Figure 1. The effect of method of feeding on body weight of pigs in experiment II.

Experiment II. The ration used in this experiment contained less calcium than that used in experiment I but only 22 ppm of zinc (table 1). Previously this ration contained from 28 to 35 ppm of zinc. The decrease could be accounted for by a lower zinc content of the corn (22 compared to 15 ppm of zinc on the dry matter basis). The effects of various methods of feeding on the average body weight of the pigs are shown in figure 1. At the end of 12 weeks there was no significant difference in weight gains of the *ad libitum,* dry-fed pigs compared to the *ad libitum,* wet-fed pigs. Hand-feeding, dry slightly increased average daily gains from 0.07 lb. per day to 0.14 lb. per day ($P<0.20$). When wetting the feed and hand-feeding were combined, gains were significantly increased to 0.53 lb. per day ($P<0.01$), but this was significantly less than that obtained by supplementation of 100 ppm of zinc (as zinc oxide) regardless of the method of feeding ($P<0.01$). When supplemental zinc was fed, method of feeding did not alter weight gains. Thus, method of feeding may affect

the availability of natural dietary zinc for the control of parakeratosis. There were no deaths due to parakeratosis in this experiment.

Figure 2 shows the average skin ratings of the pigs in experiment II. Zinc supplemented lots are not included in figure 2 because there were no symptoms of parakeratosis in these pigs. *Ad libitum*-feeding, wet and hand-feeding, dry appeared to slightly delay the development of parakeratosis but did not decrease the final skin condition when compared to *ad libitum*-feeding, dry. Hand-feeding, wet delayed the devel-

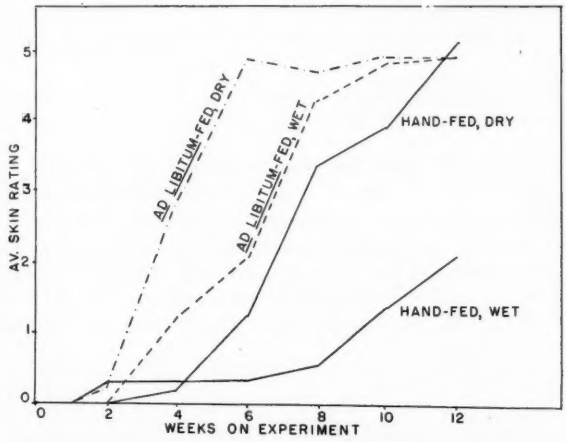

Figure 2. The effect of method of feeding on the average skin condition of pigs in experiment II. The zinc supplemented lots showed no parakeratosis and are not included on this figure.

opment of parakeratosis and lessened the severity of the skin lesions but did not prevent the appearance of parakeratosis. There were definite symptoms of parakeratosis in all pigs *not* receiving supplemental zinc. In this experiment the supplementation of the ration with 100 ppm of zinc completely prevented parakeratosis irrespective of feeding method.

The relation of method of feeding to the zinc concentration of the liver is shown in table 3. Hand-feeding, wet did not significantly affect the zinc concentration of the liver when compared to *ad libitum*-feeding, dry. When 100 ppm of supplemental zinc was fed, hand-feeding, wet did not significantly increase the zinc concentration of the liver when compared to *ad libitum*-feeding, dry.

Binding of zinc by calcium phosphates. The results of experiments relating to the binding of zinc by precipitated calcium phosphates are presented in figures 3 and 4. Figure 3 shows the effect of pH on the *in*

TABLE 3. THE RELATIONSHIP OF METHOD OF FEEDING TO THE ZINC CONCENTRATION OF THE LIVER (EXPERIMENT II)

Lot no.	Treatment	No. of samples	Av. skin rating	Zinc concentration (mcg. per gm. of D.M.[a])
1	*Ad libitum*-fed, dry	5	4.8[b]	82
4	Hand-fed, wet	6	2.0[b]	78
5	*Ad libitum*-fed, dry+100 ppm of zinc	6	0.0[c]	113[d]
6	Hand-fed, wet+ 100 ppm of zinc	6	0.0[c]	128[d]

[a] Dry matter.
[b] At the end of 12 weeks on experiment.
[c] At the end of 20 weeks on experiment.
[d] Significantly greater than lots 1 and 4 ($P<0.01$).

vitro removal of zinc from solutions containing 1% calcium, 1% phosphorous and 10 ppm of zinc. No zinc was removed from solution and no precipitation of calcium phosphates was evident until a pH of 3 or higher was reached. As the pH was increased the amount of zinc removed was also increased until 100% of the zinc was removed at a pH of 5.5 to 6.0. Both calcium and phosphorus were required for zinc to be removed from solution in this pH range. The precipitation of magnesium

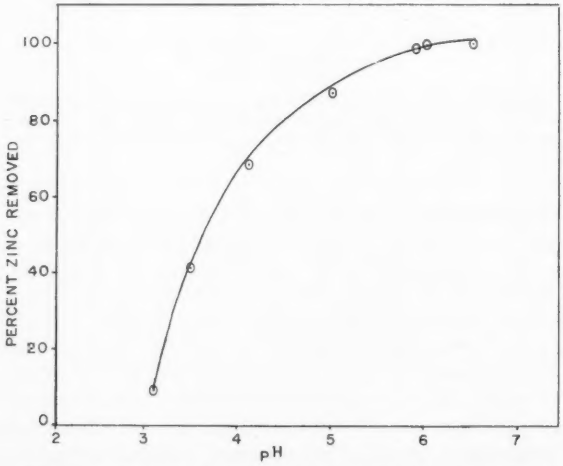

Figure 3. The effect of pH on the in vitro removal of zinc from solution. A solution consisting of $CaCl_2$, H_3PO_4 and $ZnCl_2$ contained 1% calcium, 1% phosphorus and 10 ppm of zinc. The pH of the solution was varied by the addition of redistilled NH_4OH and HCl.

phosphates also removed zinc from solution. Calcium carbonate will not precipitate from solution until the pH is above 7 and thus removed no zinc from solution under acidic conditions. At a pH of 7 or higher zinc would probably be precipitated as zinc hydroxide.

As seen in figure 3, little zinc was removed from solution at a pH below 3 which was near the pH of the pig's stomach, while all of the zinc was removed at a pH of 5.5 to 6.0 which was near the pH of the

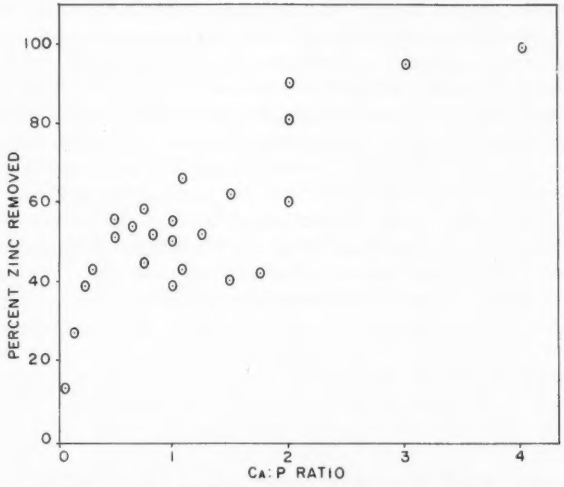

Figure 4. The effect of Ca:P ratio on the in vitro **removal of zinc from solution. A solution consisting of $CaCl_2$, H_3PO_4 and Zn Cl_2 contained 0.25% calcium, 10 ppm of zinc and the amount of phosphorus to obtain the desired Ca:P ratio. The pH was adjusted to 5.2 with redistilled NH_4OH and HCl.**

pig's small intestine (Lewis *et al.*, 1956). Although this *in vitro* system is far from physiological, this type of phenomenon may explain the detrimental effect of high calcium on parakeratosis and the decrease in zinc concentration of various tissues observed when high dietary calcium is fed to the pig.

Figure 4 shows the effect of the Ca:P ratio on the *in vitro* removal of zinc from solution by the precipitation of calcium phosphates. Solutions containing 0.25% calcium, 10 ppm of zinc and the appropriate amount of phosphorus to obtain the desired Ca:P ratio were brought to a pH of 5.2. This graph represents a series of experiments. Individual determinations are designated on the graph. As the Ca:P ratio increased from 0.08 to 4.00, the amount of zinc removed from solution also in-

creased. In the range of a Ca:P ratio of 0.5 to 3, there was considerable variation in zinc removal at a given Ca:P ratio under the conditions used. Therefore, a curve was not drawn to represent the relationship. However, a highly significant correlation coefficient of +0.816 was obtained between the Ca:P ratio and the amount of zinc removed from solution.

Discussion

In previous papers it was reported that high dietary calcium aggravated parakeratosis and decreased the zinc concentrations in certain organs or tissues of the pig (Hoekstra *et al.*, 1956; Lewis *et al.*, 1957). One explanation of this decrease in zinc concentration would be decreased absorption of zinc. The removal of zinc from solution which accompanies the precipitation of calcium phosphates may be an explanation for the decreased intestinal absorption of zinc. A similar phenomenon has been shown by Wilgus and Patton (1939) for manganese and was believed to be of importance in the calcium antagonism of manganese utilization in the chick. It is not known to what degree calcium phosphates actually precipitate in the small intestine of the pig nor how this is quantitatively related to dietary levels of calcium and phosphorus. The concentrations of calcium, phosphorus, and zinc used in the *in vitro* experiments were similar to what might be found in the intestinal contents. However, other metal-binding agents in the intestinal tract (amino acids, phytate, fatty acids, etc.) would undoubtedly complicate the relationship. If a similar binding of zinc does occur in the intestinal tract, the results obtained on varying the Ca:P ratio in the *in vitro* experiments would indicate that excessively high levels of phosphorus in a ration containing a given level of calcium should tend to alleviate parakeratosis. Experiments which test this hypothesis have not been reported, although in our earlier work (Lewis *et al.*, 1956) rather small amounts of additional phosphorus, as monosodium phosphate, to a ration did appear to lessen the skin lesions of parakeratosis but did not stimulate body weight gains.

An effect of method of feeding on parakeratosis has been demonstrated. Hand-feeding, wet gave the best protection from parakeratosis while *ad libitum*-feeding, dry (self-feeding) was the most detrimental. It is interesting that both *wetting* the feed and "limited feeding" (i.e. twice a day for 1 hour) were necessary to cause much alleviation of the skin lesions and increased weight gains of the pigs. Neither of these treatments by itself had much protective effect. In this study the combined hand-feeding, wet did not completely prevent parakeratosis of the skin nor its adverse effect on body growth. Thomas and Eden (1954) reported from field studies in England that wet-feeding prevented or cured a swine dermatitis. Presumably these pigs were also limited-fed. It is very possible that the amounts of calcium and zinc in the ration have

a profound effect on the completeness of the response from altering the method of feeding. Although the calcium level in experiment II of the presently reported experiments was not extremely high, the zinc level was the lowest reported for a natural swine ration used in parakeratosis studies. Perhaps by slightly lowering the level of dietary calcium or increasing the level of zinc to produce less severe parakeratosis, a complete protection against the disease by hand-feeding, wet can be demonstrated. The fact that method of feeding had no effect on skin lesions or on weight gains when the ration was supplemented with 100 ppm of zinc suggests that hand-feeding, wet may in some way increase the availability of zinc, at least insofar as its effect on parakeratosis is concerned. However, analyses for zinc in the livers of the hand, wet-fed pigs did *not* indicate significantly higher concentrations of zinc. Perhaps hand-feeding, wet exerts its effect by altering the relative movements of calcium, phosphorus, and zinc through the gastrointestinal tract in such a way that there is less binding of dietary and/or intestinal endogenous zinc by calcium phosphates. A differential movement of calcium and phosphorus relative to the dry matter of the ingesta through the gastrointestinal tract of swine on hand-feeding, wet has been demonstrated (Moore and Tyler, 1955). This possibility is being investigated further.

Summary

The effects of various methods of feeding on the development of parakeratosis in growing swine were studied. "High calcium" rations were fed. *Ad libitum*-feeding, dry (self-feeding) was the most detrimental, while a combination of wetting the feed and supplying limited amounts of feed only twice a day (hand-feeding, wet) significantly stimulated body weight gains and reduced the severity of the parakeratotic skin lesions. Neither *ad libitum*-feeding, wet nor hand-feeding, dry alone had much beneficial effect on parakeratosis or on weight gains. Although in this study hand-feeding, wet proved beneficial, the response was significantly less than that obtained by supplementing the ration with 100 ppm of zinc. Altering the method of feeding did not affect weight gains or produce skin lesions in pigs receiving 100 ppm of supplemental zinc. This suggests that hand-feeding, wet may increase the availability of natural dietary zinc for the control of parakeratosis.

Experiments performed *in vitro* demonstrated that zinc was readily removed from solution during the precipitation of calcium phosphates brought about by increasing from 3 to 6 the pH of solutions of calcium, phosphate and zinc. These conditions simulate somewhat the change in pH of ingesta during its passage from the stomach of the pig into the small intestine. Decreasing the Ca:P ratio of these solutions by varying the phosphate concentration markedly decreased the amount of zinc removed from solution. Possible relationships of zinc binding by calcium

phosphates to the antagonistic effects of high dietary calcium on parakeratosis in swine and to the beneficial effect of hand-feeding, wet were discussed.

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THE EFFECT OF MINERAL AND PHENOTHIAZINE SUPPLEMENTATION ON THE RESISTANCE OF GRAZING LAMBS TO *HAEMONCHUS CONTORTUS* INFECTION [1]

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University of Wisconsin [4]

EXPERIMENTS conducted in dry lot have shown that the feeding of trace mineralized salt and steamed bone meal in the ration enabled lambs to better withstand stomach worm (*Haemonchus contortus*) infection (*Richard et al.*, 1954). Similar studies conducted on pasture failed to demonstrate that steamed bone meal was necessary for maximum response to trace mineralized salt (Richard, 1952). The author attributed these results to the unpalatability of steamed bone meal when fed under these conditions. Andrews *et al.* (1943), Britton *et al.* (1943), Cauthen (1951, 1953) and others have demonstrated that phenothiazine fed continuously at low levels is helpful in the control of gastro-intestinal parasites.

The present experiments were conducted to determine the relative effectiveness of various combinations of trace mineralized salt, di-calcium phosphate and phenothiazine in alleviating the effects of stomach worm infection in grazing lambs.

Experimental Procedure

The data reported are from four experiments conducted during successive years. The experimental procedure was essentially the same for each experiment. A total of 159 spring lambs from black-faced ewes and purebred Suffolk rams were used in these studies.

Prior to being placed on pasture the ewes were drenched with one ounce of phenothiazine and the ewes and lambs were vaccinated against enterotoxemia. The lambs (1 to 2 mo. of age) were divided equally according to age and type of birth into four groups and placed on pasture with their dams.

In the 1953 experimental period (Shumard, 1956) it was necessary to rotate each group between two pasture lots to provide ample feed. During the 3 years 1954–56, each group remained on one pasture field throughout the season. The pasture used in these experiments consisted of a mixture of

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ladino clover, alfalfa and bromegrass. After approximately 4.5 months on pasture the lambs were marketed as slaughter lambs.

During the experiment the animals had access to the following supplements: Lot I, basal (trace mineralized salt [5]); Lot II, basal+25% dicalcium phosphate; Lot III, basal+10% phenothiazine; and Lot IV, basal+22.5% dicalcium phosphate+10% phenothiazine.

At approximately 2.5 months of age the lambs in all lots were infected with stomach worms by administering individual drenches containing 20,000 third stage *Haemonchus contortus* larvae. Data were collected on fecal egg counts, hemoglobin values, weight gains, carcass grades and postmortem worm counts. Fecal egg counts were determined by the method of Stoll (1930) and by a modification of the Willis-Malloy technique (Belding, 1942). Each of these methods was employed in two of the experimental periods. Hemoglobin values were determined by the oxyhemoglobin method (Hawk *et al.*, 1947).

Results and Discussion

The average pounds of the supplemental mixtures consumed in the various lots were as follows: Lot I, 17.0 lb.; Lot II, 21.5 lb.; Lot III, 12.0 lb.; and Lot IV, 13.3 lb.[6] These data show that the inclusion of phenothiazine in the supplement tended to lower consumption of the mixture.

The average numbers of stomach worm eggs passed in the feces of the lambs are shown in figure 1. After initiation of egg production, the highest average fecal egg counts were consistently found in lot I (basal). In this lot an average value of 14.4 thousand eggs per gram of feces was attained at the peak of infection. This number represents approximately three times more eggs than the highest average number produced in either Lot II or III (basal+dicalcium phosphate, and basal+phenothiazine respectively), and five times more than were produced in Lot IV (basal+dicalcium phosphate+phenothiazine). These data indicate that dicalcium phosphate and phenothiazine were equally effective in inhibiting the production of parasite eggs in parasitized lambs. A combination of dicalcium phosphate and phenothiazine appeared to be more effective in inhibiting parasite egg production than either compound fed individually.

Average hemoglobin values, determined at various intervals after infection, are shown in table 1. The initial values represent normal hemoglobin levels. A decline in the average hemoglobin values occurred in all lots 25 to 41 days after infection. This decline was most pronounced in Lots I and III (basal and basal + phenothiazine respectively) where the respective declines amounted to 3.29 and 3.16 gm. of hemoglobin per 100 ml. of blood. Significantly higher values were obtained for the same period in Lots II and IV (basal + dicalcium phosphate and basal + dicalcium phos-

[5] Trace mineralized salt was a commercial mixture of the following guaranteed analysis: 96% NaCl, 0.30% Fe, 0.150% Mn, 0.010% Co, 0.060% Cu. and 0.007% I.

[6] Averages of three experimental periods.

phate + phenothiazine) where respective hemoglobin declines amounted to only 1.68 and 1.74 gm. per 100 ml. of blood.

It appears from these results that dicalcium phosphate was more effective than phenothiazine in reducing the severity of the anemia which developed during the earlier part of the infection period. As the infection progressed, however, hemoglobin values appeared to be in favor of the

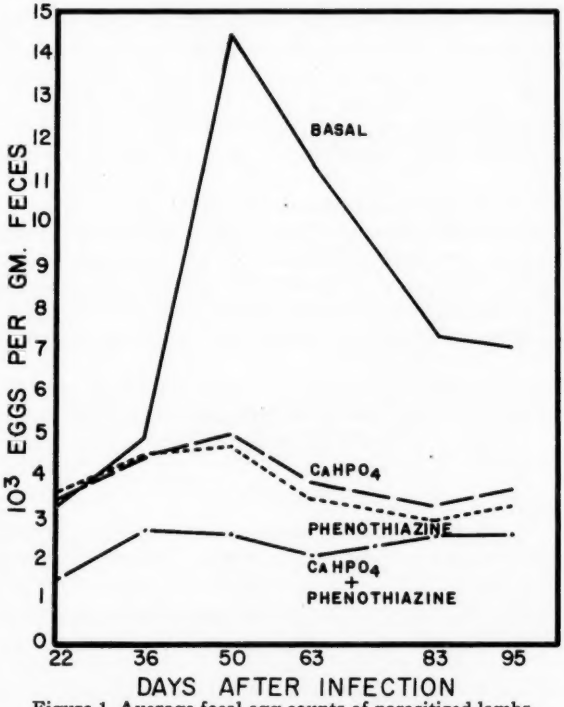

Figure 1. Average fecal egg counts of parasitized lambs receiving various dietary supplements.

lots receiving phenothiazine. The highest post-infection hemoglobin values were obtained during the latter part of the infection period when dicalcium phosphate and phenothiazine were fed together.

When trace mineralized salt was fed (Lot I), 27.5% of the lambs succumbed to the infection. When dicalcium phosphate and/or phenothiazine was fed this death loss was reduced to 0% in Lot II, 2.6% in Lot III, and 5.0% in Lot IV.

The average weight gains are presented in table 2. Significant increases in weight gains were observed during two of the four experimental periods

TABLE 1. AVERAGE HEMOGLOBIN VALUES OF PARASITIZED LAMBS AT VARIOUS INTERVALS AFTER INFECTION

(Gm. Hb. per 100 ml. Blood) [a]

Treatment	Total number of lambs	Days after infection			
		0	25–41	61–67	90–98
Basal	40	12.86	9.57	8.76 (3)	9.19 (8)
Basal+$CaHPO_4$	40	12.61	10.93**	10.70	10.09
Basal+phenothiazine	39	12.55	9.39	10.13 (1)	10.62
Basal+$CaHPO_4$+ phenothiazine	40	12.57	10.83**	11.20	11.13 (2)

[a] Data were obtained over a 4-year period.
Numbers in parentheses indicate the number of deaths.
** Significant at the 1% level of probability.

in Lots II and IV (basal + dicalcium phosphate and basal + dicalcium phosphate + phenothiazine respectively) and during one experimental period in Lot III (basal + phenothiazine). The average weight gained during the four experimental periods in Lots II, III and IV represented respective increases of 4.2, 7.7 and 7.6 lb. over the weight gain of Lot I (basal). These differences were not significant, but indicate that there was a tendency

TABLE 2. THE EFFECT OF MINERAL AND PHENOTHIAZINE SUPPLEMENTATION ON DEATH LOSS, WEIGHT GAINS AND CARCASS GRADES OF PARASITIZED SHEEP

Item	Treatment			
	Basal	Basal+ $CaHPO_4$	Basal+ phenothiazine	Basal+ $CaHPO_4$ phenothiazine
Total number of lambs	40	40	39	40
Death loss, %	27.5	0	2.6	5.0
Av. weight gain, lb.[a]				
1953	30.3	35.8**	32.8	40.5**
1954	26.2	24.2	33.1	31.0
1955	48.6	60.9**	66.0	57.1*
1956	54.7	55.6	58.5	61.5
Av.	39.9	44.1	47.6	47.5
Av. carcass grade [b]				
1953	1.3	3.8	4.0	5.9
1954	7.3	9.3	10.2	8.5
1955	6.6	10.1	9.9	9.3
1956	10.1	10.9	11.1	12.1
Av.	6.3	8.5**	8.8**	8.9**

[a] Includes the weight increase of each lamb until the time of death or slaughter.
[b] The following scores were assigned: cull 2, utility 5, good 8, choice 11, prime 14.
* Significant at 5% level of probability.
** Significant at 1% level of probability.

for dicalcium phosphate and/or phenothiazine to increase weight gains of parasitized lambs.

The average carcass grades presented in table 2 show that the average grade obtained in Lot I (basal) was approximately high utility. The average grades for the lots receiving dicalcium phosphate and/or phenothiazine were approximately three-fourths of a grade higher. These differences were statistically significant at the 1% level of probability. These data on carcass grades further show a similarity in the effects of feeding dicalcium phosphate and phenothiazine to parasitized sheep.

Post-mortem worm counts made on abomasums collected at the time of slaughter are indicative of the level of infection existing only at the termination of the experiment. The arithmetic mean of the average worm counts obtained during the four experimental periods are 3,251, 3,515, 2,140 and 2,167 for Lots I, II, III, and IV respectively. Direct comparisons involving Lot I (basal) cannot be taken as conclusive because of the large number of animals in this lot that died prior to the time of slaughter. The average worm counts for Lot II (basal + dicalcium phosphate) were one-third higher than the number found in either lot III or IV which received phenothiazine incorporated into the supplement. This higher worm count was probably an important factor in bringing about the lower hemoglobin values obtained for Lot II at 90–98 days after infection.

A highly significant correlation of hemoglobin values with fecal egg counts was found to exist in these studies. This correlation expressed mathematically was found to be —0.74.

Summary

Experiments were conducted during four successive years to determine the relative effectiveness of various combinations of trace mineralized salt, dicalcium phosphate and phenothiazine in alleviating the effects of stomach worm infection in grazing lambs. The results show that the feeding of trace mineralized salt, supplemented with either dicalcium phosphate or phenothiazine, was superior to the unsupplemented salt ration in reducing the injurious effects of stomach worm infection. Lambs fed dicalcium phosphate exerted a resistance to the effects of stomach worm infection that was approximately equal to that obtained by the use of phenothiazine. Best results were obtained, however, from the feeding of a combination of dicalcium phosphate and phenothiazine.

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ASCARICIDAL ACTIVITY OF PIPERAZINE ADMINISTERED IN THE FEED TO SWINE

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THE efficacy of piperazine for removal of *Ascaris lumbricoides*, the large round worm of swine has been reported by Sloan *et al.* (1954), Leiper (1954), Enzie and Colglazier (1955), and Shumard and Eveleth (1955). The drug is acceptable to hogs in the drinking water and when consumed at the rate of 50 mg. per pound of body weight is a highly effective and safe ascaricide (Guthrie, 1956).

A critical test conducted by Leiper (1954), showed that piperazine carbodithioic acid administered in the feed was 100% effective against Ascaris at a dosage of 100 mg. per kilogram of body weight in 3 pigs. Further critical information is limited on the efficacy of the simple piperazine compounds administered in the feed to hogs. Three available compounds which could be used in feed are piperazine dihydrochloride (51% piperazine), piperazine sulfate (46.8% piperazine), and piperazine phosphate (41% piperazine). A series of critical experiments were conducted to evaluate the comparative ascaricidal activity of these piperazine compounds.

Experimental Procedure

The pigs used in the tests reported herein were of various breeds. They were purchased in small groups from various farms in the vicinity of Ashland. All animals were confined separately in concrete-floored pens for the duration of the test. They were given sufficient time to become acclimated to the experimental pens before treatment was instituted. Feces from each animal were examined by the salt flotation method to establish that they were infected with *A. lumbricoides*.

The drugs were thoroughly mixed into the feed and the medicated ration fed for 24 hours with no prior fast. A record was kept of the amount of medicated feed consumed by each pig during the 24-hour treatment period.

Following treatment, the feces from each animal were collected at frequent intervals each day for 7 days, and screened for Ascarids in the usual manner. At the conclusion of the 7-day test period all animals were necropsied and the intestinal tract of each pig was carefully examined for Ascarids. The efficacy of treatment was determined by comparing the number of worms eliminated with the total number harbored by the animal.

Results and Discussion

Observations on the efficacy of various concentrations of piperazine sulfate, piperazine phosphate and piperazine dihydrochloride for the removal of *A. lumbricoides* from 81 infected pigs are reported in table 1. In the eight experiments reported therein, the drugs were incorporated into the feed at the concentration indicated and fed for 24 hours. For each drug used, the dosage is reported as milligrams of anhydrous piperazine per pound of body weight. At the levels used, the three drugs were readily consumed in the feed without a prior fast period.

TABLE 1. EFFICACY OF VARIOUS LEVELS OF THREE PIPERAZINE COMPOUNDS FOR THE REMOVAL OF *ASCARIS LUMBRICOIDES* FROM SWINE

Experiment No.	Number of pigs	Mean weight at treatment	Drug	Concentration	Dosage of piperazine mg./lb.		Total No. worms		Efficacy of treatment
					Mean	Range	Eliminated	At necropsy	
		lb.		%					%
1	11	100.6	P S[a]	0.4	44.6	39.5–59.6	139	17	89.1
2	7	104.6	P S	0.42	41.4	35.0–52.0	96	7	92.2
3	6	69.2	P S	0.44	51.8	35.0–66.0	110	9	92.4
4	17	58.8	P S	0.45	73.6	32.2–98.8	244	42	85.3
5	12	59.6	P HCl[b]	0.4	52.0	35.5–66.4	304	6	98.1
6	11	59.1	P PO_4[c]	0.25	33.2	18.3–44.0	77	80	49.0
7	10	49.8	P PO_4	0.33	41.6	17.1–57.4	114	76	60.0
8	7	91.1	P PO_4	0.49	54.2	27.6–63.9	115	0	100.0

[a] Piperazine sulfate.
[b] Piperazine dihydrochloride.
[c] Piperazine phosphate.

When the three compounds were used in concentrations which furnished equivalent amounts of piperazine in the feed, a 0.44% level of the sulfate, at an average dosage rate of 51.8 mg. piperazine per pound of body weight, removed 92.4% of 119 Ascarids from 6 pigs weighing 69.2 lb. With a mean piperazine dosage of 52 mg. per pound, a 0.4% level of the dihydrochloride removed 98.1% of 310 worms from 12 pigs averaging 59.6 lb. A 0.49% concentration of the phosphate removed 100% of 115 worms from seven 91 lb. pigs which consumed an average of 54.2 mg. piperazine per pound of body weight. The efficacy of treatment with equivalent piperazine levels of the three drugs administered in the feed indicates that they are approximately equal in ascaricidal activity.

Piperazine sulfate is hygroscopic in character and would be less desirable for use in feeds than the phosphate or the dihydrochloride, neither of which possess this undesirable property. It is possible that the sulfate could be incorporated into a suitable carrier which would minimize its hygroscopic character.

Summary

Three simple piperazine compounds, piperazine sulfate, piperazine dihydrochloride and piperazine phosphate were given at different levels in

the feed for 24 hours to 81 parasitized hogs. The three drugs were equally acceptable when given in the feed without a prior fast period. When fed at levels which furnished an equivalent amount of anhydrous piperazine in the feed, the dihydrochloride and the phosphate were slightly superior to the sulfate in ascaricidal activity.

Six pigs given 0.44% piperazine sulfate in the feed for 24 hours, consumed an average of 51.8 mg. piperazine per pound of body weight and eliminated 92.4% of 119 Ascarids. Twelve pigs given 0.4% piperazine dihydrochloride in their feed for the same period of time eliminated 98.1% of 310 Ascarids with a mean dosage of 52 mg. piperazine per pound of body weight. At a concentration of 0.49% in the feed, piperazine phosphate removed 100% of 115 Ascarids from 7 pigs which consumed an average of 54.2 mg. piperazine per pound of body weight.

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THE RELATIONSHIP OF RATION AND INHERITANCE TO EATING QUALITY OF THE MEAT FROM YEARLING STEERS [1, 2, 3]

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VARIATION in eating quality (juiciness and tenderness) of steaks from the same muscle cooked by the same method but from different animals has been reported by Cover and Smith (1956). Differences in eating quality might be expected to result among animals differing in heredity or level of concentrates fed. These relationships will be presented in this paper. Other relationships will be presented in subsequent papers.

Experimental Procedure

The data for these studies were obtained from 38 steers bred and raised at the McGregor Substation. All of these steers were from high grade Hereford cows. Twenty were sired by five purebred Brahman bulls and 18 by four purebred Hereford bulls. The dams had been randomly assigned to these sires as a part of a larger group. The calves were dropped in March, April and May of 1953 and were run with their dams until weaning. The male calves from all grade Hereford cows were castrated at one to two weeks of age except for the oldest male from each Brahman sire which was left uncastrated for another purpose. All cows and calves were in the same pasture except for 90 days starting April 10th when the herd was randomly assigned to 14 small breeding pastures. The calves were not given supplemental feed until after weaning in October. They were placed in a rate of gain test (Warwick and Cartwright, 1955) from November until in May of the next year. Four steers were randomly chosen from each sire group for this study. Two additional steers from sire H-27 were added because of a particular interest in sampling meat from his progeny. Half of the animals from each sire were fed a roughage ration (35% concentrates and 65% hay) and the others a concentrate ration (70% concentrates and 30% hay). In this series of papers these rations will be called growing and fattening rations, respectively.

The steers were slaughtered in May, 1954 within two weeks after the

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end of the test period. Delivery was made to the Meats Laboratory on the campus at College Station the afternoon before slaughter. A trucking distance of a little more than 100 miles resulted in approximately 3% shrinkage. The carcasses were graded to one-third grade by the Supervisor of U.S.D.A. Grading for the Texas-Oklahoma area. The carcasses were aged at about 36° F. for seven days. Slaughter and carcass data were recorded following the recommendations of Deans (1951) and Naumann (1951). Estimations of lean, fat and bone, and standard cutting tests were made according to Hankins and Howe (1946). Data from these steers have been used in carcass studies by Butler *et al.* (1956).

Three-quarter inch steaks were obtained at the time the carcass studies were made. The steaks were wrapped individually, frozen at —20° F. and stored at 0° F. until the tests could be made. Four test series for each animal were cooked: two cuts (loin and bottom round) each of which was cooked by two methods (broiling and braising). The steaks were cooked well-done. For the broiled steaks, the broiler were preheated to and regulated at 200° C. (392° F.). The steaks were browned well on one side (approximately 25 minutes), turned, and browned on the other side (approximately 10 minutes). The braised steaks were browned in a heavy pot under standardized conditions, placed on a rack above boiling water, covered and steamed for 45 minutes. The method of determining the end point of cooking was described by Cover and Smith (1956). Paired cuts from the right and left sides of the same animal were cooked—one by broiling and its pair mate by braising. Use of two pairs of cuts permitted broiling a steak from the left and right side of the animal and braising a steak from each side. The entire steak was cooked, but after cooking an individual muscle was used for scoring and shearing tests. The muscles used were: *longissimus dorsi* in loin and *biceps femoris* in bottom round.

Shear force values were obtained with a Warner-Bratzler shearing device. Four cores one-half inch in diameter were obtained—two at one end of the steak and two at the other. The cores were so thin that only one shear from each core was obtained, making a total of four shears from each steak.

Eating quality was scored by a panel of five judges. Composition of the judging committee was uniform throughout the test. The samples for the judges were narrow strips of meat—not an entire steak—taken from the area in the central portion of the steak and between the two sets of cores. Each sample from a broiled steak was paired with a sample from a similar position in the braised steak of the pair. The judges used a score card of adjectives weighted from 0 to 10 wherein: 10 is *excellent;* 9 *very good;* 7 *good;* 5 *medium;* 3 *poor;* 1 *very poor;* and 0 *unacceptable.* The meat was scored for juiciness and tenderness.

Judges' scores have the disadvantage that the standards of the judges may not remain the same throughout the test, particularly if sampling

periods are widely separated. Under these conditions, the standards of the judges may have been different at different judging sessions, but an effort was made to remove biases from such differences by randomizing in a stratified manner among animals, sires and breeds and also within animals, sires, breeds and rations. Eight samples were tested at each judging session. They were broiled and braised loin, and broiled and braised bottom round from each of two animals. At another session on the same day or the next day, the second pair of steaks from each cut from the same animals was tested. In this way an attempt was made to prevent bias in the comparisons among the four test series. The two animals tested at one judging session were from the same sire but not from the same ration. The remaining progeny of each sire appeared much later in the order of testing.

TABLE 1. OUTLINE OF ANALYSES OF VARIANCE

Source of variation	Degrees of freedom	Error term
Rations	1	R x S(B)
Breeds	1	S(B)
Breeds x rations	1	R x S(B)
Sires within breeds	7	A
Rations x sires within breeds	7	A
Animals	20	
Total	37	

Shear force values are not subject to this disadvantage but among research workers there is not complete agreement that shear force values are an entirely satisfactory measure of tenderness. However, coefficients of correlation between tenderness scores and shear force values for the data in this study were: broiled loin —.839; braised loin —.891; broiled bottom round —.730; and braised bottom round —.863.

Studies of the eating quality of this beef have been reported by Cover and Smith (1956) and the relationship of fatness to eating quality by Cover *et al.* (1956).

Analyses of variance were calculated to learn the association of ration and inheritance to the three measures of eating quality obtained in each of the four series of cooking tests. The calculations were made according to the outline in table 1.

Results and Discussion

Because other important management factors were similar by design for these 38 steers, ration and inheritance seemed a logical starting point in the search for the cause of the variation in eating quality which Cover and Smith (1956) attributed to differences among animals.

Ration. Since fattening rations are higher in concentrates than growing rations, they are expected to increase the gains and fatness of the live animal and to cause an improvement in the eating quality of the meat. These effects, however, may not be so apparent in shortfed yearling steers as in longer fed older cattle. In this study, the two rations differed widely in the amount of concentrates, approximately 35% versus 70%. Both rations were completely ground and mixed and available continuously in self feeders. The calves were placed on the 140-day rate of gain test shortly after weaning and their age at slaughter was under 16 months.

Under these conditions the effect of ration on juiciness and tenderness was not significant in loin steaks cooked by either method but it was significant in bottom round steaks cooked by only one method—broiling (tables 2, 3, 4). There was no significant interaction between breeds and rations. Thus, in these tests, feeding the higher concentrate ration for 156 days (140 days on gain test plus 16 days after the test before slaughter) did not significantly improve the eating quality of the loin steaks from these yearling steers but appeared to improve only the broiled bottom round steaks.

Inheritance. Evidence of the influence of inheritance may be shown either by differences between breeds or by differences among sires within breeds. In the present study, the analyses of variance indicated that the loin steaks cooked by both methods were significantly more juicy when they came from these Hereford steers than when they came from these crossbreds (table 2). But for bottom round steaks statistical significance was found only when they were broiled, with the Herefords having the higher juiciness scores. In contrast, however, breed had no significant effect on either the tenderness scores or the shear force values of these steaks (tables 3 and 4).

Sires within breeds appear to have had no significant effect on juiciness in these tests but the effect on tenderness was significant (tables 2, 3, 4). It may be noted that the average of the steaks from the animals sired by the Brahman sire No. 119 were at the bottom of the group of Brahman sires for tenderness in both cuts by both methods of cooking. On the other hand, the average of the steaks from the offspring of the Brahman sire No. 115 were at the top of the group of Brahman sires for tenderness in both cuts by both methods of cooking. Steaks from some of the crossbreds compared favorably with the tenderest steaks from the Herefords (table 5) but some were less tender than any of the steaks from the Herefords. These least tender steaks came from two steers sired by the Brahman bull No. 119. Coefficients of variability computed within breeding groups are higher for the crossbreds than for the Herefords for all measures of eating quality listed in table 5.

Thus, depending on the sires used, it would appear logical that some research groups might report meat from animals of Brahman or part

TABLE 2. JUICINESS SCORES AVERAGED BY BREEDS,[a] RATIONS, BREEDS × RATIONS AND SIRES WITHIN BREEDS

Variables	Number of animals averaged	Juiciness scores [b]			
		Loin [c]		Bottom round [c]	
		Broil	Braise	Broil	Braise
Rations					
Growing	19	6.5	5.4	7.4	5.6
Fattening	19	6.6	5.0	8.3	5.4
Sig. of difference		n.s.	n.s.	**	n.s.
Breeds [a]					
Hereford	18	6.9	5.5	8.0	5.6
Brahman x Hereford	20	6.2	4.9	7.7	5.4
Sig. of difference		**	**	*	n.s.
Breeds x rations [a]					
Hereford Growing	9	6.8	5.6	7.7	5.7
Fattening	9	6.9	5.4	8.3	5.5
B x H Growing	10	6.2	5.1	7.2	5.5
Fattening	10	6.3	4.7	8.2	5.4
Sig. of difference		n.s.	n.s.	n.s.	n.s.
Sires within breeds [a, d]					
H–27	6	6.8	5.5	8.1	5.7
H–90	4	7.2	5.8	8.2	5.9
H– 7	4	6.6	5.5	7.9	5.7
H–89	4	6.9	5.3	7.7	5.0
B–115	4	6.3	4.9	7.8	5.6
B–120	4	6.2	5.2	7.9	5.4
B–117	4	6.1	5.1	7.7	5.8
B–113	4	6.2	4.7	7.7	5.6
B–119	4	6.3	4.7	7.5	4.8
Sig. of difference		n.s.	n.s.	n.s.	n.s.

n.s. Not significant.
* Significant at 5% level.
** Significant at 1% level.
[a] The breed of sire was either Hereford or Brahman but all of the dams were Hereford.
[b] See footnote b, table 3.
[c] The entire piece of meat was cooked but only the portion inside the muscle sheath was scored or sheared.
[d] This analysis included 3 degrees of freedom for Hereford sires pooled with 4 degrees of freedom for Brahman sires.

Brahman breeding to be tougher than that from Herefords and for others to report no difference in tenderness between the two breeds. In fact, the Florida workers (Carpenter *et al.*, 1955) have reported that steaks and roasts from animals of part Brahman breeding were less tender than those of Shorthorn breeding but Butler, King and Cover (unpublished data) have found that steaks from some animals with Brahman or part Brahman breeding were as tender as those with all Hereford breeding.

TABLE 3. TENDERNESS SCORES AVERAGED BY RATIONS, BREEDS,[a] BREEDS × RATIONS AND SIRES WITHIN BREEDS

Variables	Number of animals averaged	Tenderness scores [b]			
		Loin [c]		Bottom round [c]	
		Broil	Braise	Broil	Braise
Rations					
Growing	19	6.3	6.7	6.3	7.6
Fattening	19	6.7	6.8	7.4	8.3
Sig. of difference		n.s.	n.s.	*	n.s.
Breeds [a]					
Hereford	18	6.8	7.2	7.3	8.5
Brahman x Hereford	20	6.3	6.3	6.5	7.5
Sig. of difference		n.s.	n.s.	n.s.	n.s.
Breeds x rations [a]					
Hereford Growing	9	6.6	7.4	6.8	8.4
Fattening	9	6.9	7.0	7.7	8.6
B x H Growing	10	6.0	6.1	5.8	6.9
Fattening	10	6.6	6.6	7.2	8.1
Sig. of difference		n.s.	n.s.	n.s.	n.s.
Sires within breeds [a, d]					
H–27	6	7.2	7.4	7.3	8.4
H–90	4	7.1	7.4	7.6	8.9
H– 7	4	6.6	6.8	7.6	8.9
H–89	4	6.2	7.1	6.7	7.9
B–115	4	7.5	7.8	6.8	8.2
B–120	4	7.0	7.1	6.8	8.0
B–117	4	6.9	7.4	6.7	7.9
B–113	4	5.5	4.9	6.7	7.0
B–119	4	4.5	4.5	5.4	6.4
Sig. of difference		*	*	n.s.	*

n.s. Not significant.
* Significant at 5% level.
[a] The breed of sire was either Hereford or Brahman but all of the dams were Hereford.
[b] Weighting of adjectives: 0–0.4 unacceptable; 0.5–1.9 very tough; 2.0–3.9 tough; 4.0–5.9 neither tough nor tender; 6.0–7.9 tender; 8.0–9.4 very tender; 9.5–10 extremely tender.
[c] The entire piece of meat was cooked but only the portion inside the muscle sheath was scored or sheared.
[d] This analysis included 3 degrees of freedom for Hereford sires pooled with 4 degrees of freedom for Brahman sires.

No attempt is made here to draw conclusions on the tenderness of meat from the entire population within a breed from these small numbers of animals. Yet the observations in this study on breeds and sires within breeds, when taken together, lend support to the hypothesis that the heredity of the animal influences the juiciness and tenderness of the meat.

The influence of heredity on tenderness of beef has been suspected

TABLE 4. SHEAR FORCE VALUES AVERAGED BY RATIONS, BREEDS,[a] BREEDS × RATIONS AND SIRES WITHIN BREEDS

Variables	Number of animals averaged	Shear force in pounds [b]			
		Loin [c]		Bottom round [c]	
		Broil	Braise	Broil	Braise
Rations					
Growing	19	10.2	10.2	9.0	6.0
Fattening	19	9.6	9.7	8.4	5.7
Sig. of difference		n.s.	n.s.	*	n.s.
Breeds [a]					
Hereford	18	9.5	9.1	8.5	5.4
Brahman x Hereford	20	10.3	10.7	8.8	6.3
Sig. of difference		n.s.	n.s.	n.s.	n.s.
Breeds x rations [a]					
Hereford Growing	9	9.8	9.4	8.6	5.3
Fattening	9	9.2	8.8	8.5	5.4
B x H Growing	10	10.6	11.0	9.3	6.7
Fattening	10	10.0	10.4	8.3	6.0
Sig. of difference		n.s.	n.s.	n.s.	n.s.
Sires within breeds [a, d]					
H–27	6	9.3	9.1	8.2	5.1
H–90	4	8.7	8.3	8.2	5.0
H– 7	4	10.1	9.6	8.6	5.2
H–89	4	9.9	9.4	9.3	6.2
B–115	4	8.8	8.7	7.7	5.5
B–120	4	9.0	8.8	8.8	5.7
B–117	4	9.8	9.9	8.8	5.6
B–113	4	11.6	12.3	9.0	7.1
B–119	4	12.3	13.9	9.7	7.8
Sig. of difference		n.s.	*	*	*

n.s. Not significant.
* Significant at 5% level.
[a] The breed of sire was either Hereford or Brahman but all of the dams were Hereford.
[b] Cores were ½-inch in diameter. The least tender meat required more pounds to shear.
[c] The entire piece of meat was cooked but only the portion inside the muscle sheath was scored or sheared.
[d] This analysis included 3 degrees of freedom for Hereford sires pooled with 4 degrees of freedom for Brahman sires.

for some time, although conclusive published data are lacking. Black *et al.* (1934) reported that the roasted meat of the Brahman-Shorthorns was less tender than that of the Herefords or the Shorthorns. The average resistance being 37.3 lb. for 6 Brahman-Shorthorns as compared with an average of 25 lb. for the 2 Herefords, and 35 lb. for the 4 Shorthorns. However, the wide variations observed among individual animals in the different groups were thought by the authors to indicate "possibilities for improvement which selection and breeding methods now offer

to the energetic worker in the field". Hostetler *et al.* (1936) compared the offspring of a native bull and native cows with offspring of a purebred Hereford bull and native cows. Roasted 9-10-11 ribs from the progeny of the purebred Hereford bull were significantly more tender than those from the progeny of the native bull, but the average values for both fell within "tender" in terms of the grading chart used. The Chief of the Bureau of Animal Industry (1937) reported "Two Hereford bulls, rather closely related and of apparently equal quality, were bred to beef cows of similar breeding. The calves of one of the bulls made more rapid gains and their carcasses had higher dressing percentages than did the

TABLE 5. RANGE IN TENDERNESS

Cut, method of cooking and breed [a]	Scores [b]			Shears [c]		
	Toughest	Tenderest	Coefficient of variation	Toughest	Tenderest	Coefficient of variation
			%			%
Loin						
Broil						
H	5.0	8.4	15.61	12.9	7.6	15.71
B x H	2.6	9.0	25.09	14.5	7.0	18.62
Braise						
H	5.7	9.2	13.27	13.8	6.9	19.00
B x H	3.6	9.7	29.04	15.2	6.2	25.60
Bottom round						
Broil						
H	6.2	8.7	8.65	9.8	7.6	14.86
B x H	3.2	8.3	38.68	11.1	7.4	25.14
Braise						
H	7.4	9.5	15.91	7.2	4.1	20.04
B x H	3.9	8.7	25.67	9.8	4.1	40.28

[a] The sires were either Hereford or Brahman, but all the dams were Hereford.
[b] Average of 10 judgments (5 from each of two steaks) from one animal. The highest scores were given to the most tender meat.
[c] Average of 8 shears (4 from each of two steaks) from one animal. The least tender meat required the most force to shear.

calves of the other bull. When the rib cuts of the carcasses were roasted in a similar manner, the superiority observed in the growth of the first bull was again present in the form of more tender meat." Hiner and Yao (1954) gave no data but stated "Heritability coefficients estimated by the half-sib method, show that when the high level of heritability is set at 40%, the following factors may be effectively selected for: size of eye, length and width of eye, ether extract fat, marbling intensity and desirability of lean, quality of juice and resistance to shearing." The extensive work on heritability at Miles City (Woodard *et al.*, 1954) was concerned with preslaughter and carcass characteristics only.

In the present study, with 9 sires represented and 4 series of cooking tests for each of 38 animals, there was an opportunity for testing the heritability of tenderness. Differences in tenderness scores and shear

force values for sires within breeds were statistically significant in three out of four series, although the other two series approached the .05 level in each case. Since these data indicated that heredity has an important influence on tenderness, heritability estimates were computed for tenderness scores and for shear force values of those which were above the .05 level. These estimates proved to be quite variable (table 6). Three of the six were 100% or over and obviously have a multiplied error or bias. Considerable sampling error may be introduced into heritability estimates computed by the half-sib intraclass correlation method. Environmental correlations between relatives may have biased these estimates also, although complete randomization, within practical means, was attempted.

TABLE 6. HERITABILITY ESTIMATES FOR TENDERNESS SCORES AND SHEAR FORCE VALUES COMPUTED BY THE HALF-SIB INTRACLASS CORRELATION METHOD

Method of assessing tenderness	Broiled loin	Braised loin	Broiled bottom round	Braised bottom round
	%	%	%	%
Tenderness scores	71	119	—	28
Shear force values	—	102	86	100

Variability due to differences in temperament of the steers, which the authors now believe may be important, could not be isolated in the data used in this study. Brahman sire No. 115, whose offspring had the most tender meat within this breed, was quite gentle and could be handled with ease. In contrast, Brahman sire No. 119 whose offspring had the least tender meat was unruly and pugnacious. In another study the average temperament scores of the heifer offspring of a few of the sires reported here ranked as follows (from most to least desirable): H-7, B-113, B-117 and B-119. No connection between temperament and tenderness is known at present, but it appears logical that certain physiological conditions related to temperament may be related to tenderness also. This reasoning provides a basis for a series of related observations which will be made as this study continues.

It is well recognized that a single score for tenderness, such as was obtained on the meat from these steers, is a composite of impressions coming from connective tissue and from muscle fibers. It may be that the tenderness of each of these tissues is affected to different degrees by inheritance and environment. Tenderness of muscle fibers and tenderness of connective tissue are always confounded in shear force values and in tenderness scores. The possibility of separating the two sources of tenderness will be explored in subsequent studies with other animals.

Evaluation of breeding animals is a problem since no suitable, quick

method of live animal evaluation for tenderness is now available. The usual progeny testing may be helpful but is very slow and costly if used extensively. Blood chemistry studies are being made and may be helpful. Biopsy techniques may prove feasible, but it is doubtful if sufficient tissue for organoleptic tests could be obtained. Simpler tests which require no cooking, even if usable only on slaughtered cattle, would be advantageous. Identification of the chemical compounds responsible for tenderness or toughness would simplify this problem greatly.

The influence of heredity on tenderness may be associated with certain physiological or metabolic variations. Such variations might influence not only tenderness but also such gross characteristics as weight, gain, fat deposition and the development of muscular tissue. The level of certain chemical compounds in the blood may also be hereditary. Such a characteristic in the live animal or in the carcass might serve as an indicator of tenderness. Such considerations will be discussed in subsequent papers of this series.

Summary

Analyses of variance were calculated to determine the effect of ration, breed and sires on juiciness and tenderness of loin and bottom round steaks cooked by broiling and braising. There were 18 purebred Hereford steers from 4 sires and 20 Brahman x Hereford steers from 5 Brahman sires. All of these steers were from Hereford dams. The rations were high concentrates versus high roughage. Feeding the higher concentrate ration for 156 days did not significantly improve the eating quality of the loin steaks from these yearling steers but appeared to improve only the broiled bottom round steaks. Breed of sire had a significant effect on the juiciness of some of these steaks but no significant effect on tenderness. Sires within breeds had no significant effect on juiciness but their effect on tenderness was significant. Heritability estimates were calculated for each measure of tenderness (scores and shears) and for each cut and method of cooking. These estimates ranged from 28% to 119% for scores and 74% to 102% for shears. At least some of them must be biased upward indicating confounding of inheritance and environment.

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A PHOTOGRAPHIC GRID USED TO MEASURE RIB EYE AREAS [1]

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TO evaluate beef carcasses objectively, several techniques have been developed to estimate the extent of muscular development or meatiness and the percentage of fat and lean without manual separation and weighing. The cross section of the longissimus dorsi muscle, referred to as the rib eye, is used extensively by research workers as a standard procedure in evaluating carcass merit in beef cattle. The worth of this measurement has been demonstrated by numerous workers. Heritability estimates of the measurement as reported by Knapp *et al.* (1946) (1950) and by Shelby *et al.* (1955) ranged from 68 to 72%. Woodward *et al.* (1954) found area of rib eye significantly correlated with birth weight, weaning weight, gain on test, slaughter grade, carcass grade, length of leg, and length of body in a detailed analysis of performance data on 635 head of Hereford steers. Cahill *et al.* (1956) reported a correlation of .85 between area rib eye and percentage of edible portion of the carcass.

The rib eye area is generally obtained by reproducing the rib cut on tracing paper, drawing in the fat and lean portions, and measuring this area by planimeter. Qualitative differences such as color, marbling and connective tissue are not recorded in the tracing. In order to retain some of these quality factors, color photography has been used to record and measure the rib eye area.

Materials and Methods

An Argus C-3 Camera fitted with a Kodak No. 3 portrait lens was used. A close-up attachment was built according to specifications given in Kodak pamphlet No. B-10. The field of this particular attachment is 6¼ x 9⅜ inches, which is adequate to cover the beef rib cut. Two reflector-type RFL2 photographic flood lamps were attached to provide adequate lighting. For measurement purposes a rectangular steel frame was constructed from ¼ x ½ inch bar iron with the inside dimensions the same as the end of the focal frame, 6¼ x 9⅜ inches. Two metal J-shaped clips were welded to the top of the metal frame and one on each side to attach the grid to the focal frame. Holes were drilled at ¼ inch intervals around the frame and these were threaded with a light green fishing line. The finished grid as it appears on a rib cut is shown in figure 1.

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In use (figure 2) the grid is placed over the rib eye with the grid resting on the projection of the spinal process and the 12th rib. Some care must be exercised in making the 12th–13th rib cut so that a smooth, relatively flat plane is offered for photographing.

Excellent results have been obtained using Type A Kodachrome film (now available in 36 exposure rolls as Kodachrome Type A professional film), using an exposure of f8 at a 50th of a second. However, an exposure meter should be used to aid in determining correct camera settings.

The finished colored 2 x 2 slides may be projected on a white cardboard or screen for ease in determining rib eye area. Only those squares which are filled with one-half or more of lean tissue are counted. The number of squares counted, when divided by 16, gives the area in square inches. A table top viewer may also be used successfully for counting the ¼ inch squares. If linear measurements are desired, the projector may be adjusted so that each ¼ inch square is enlarged to exactly a 1-inch square on the screen. Measurements thus taken are divided by 4 to arrive at the true values.

Discussion

The photographic grid has proved very successful in measuring rib eye areas of beef. The retention of color, marbling, connective tissue, and other quality factors of the cut has made this method especially valuable. The 2 x 2 slides can be easily filed for between-year and sire comparisons. This advantage has been extremely valuable in the analysis of carcass data on performance-tested cattle collected at this station.

The proportion of lean and fat in the rib cut can also be determined from the photograph. Wuthier (1957) estimated the proportion of lean by the formula:

$$\text{Proportion of lean} = \frac{\text{rib eye area}}{\text{rib eye area plus area of external fat}}$$

Area of external fat was determined by plotting two perpendicular lines at either end of a straight line drawn through the long axis of the longissimus dorsi muscle. The external fat within the boundry of these two perpendicular lines was measured in the same manner as rib eye area, for an estimate of area of fat. The rib eye area was measured as previously described. The correlation between the proportion of lean as determined by specific gravity of the 9, 10 and 11th rib cut and by the photographic measurement was highly significant, ($r: +.86$, $n=47$). These limited data would indicate that the area of external fat and the area of rib eye as determined from the photographic grid method may be directly related to carcass composition.

The ease and speed with which the tool can be used has proved to be particularly advantageous while collecting data at custom slaughtering houses. Since few experiment stations have facilities to slaughter all experimental animals at the institution, the advantage of the tool in this respect is very evident.

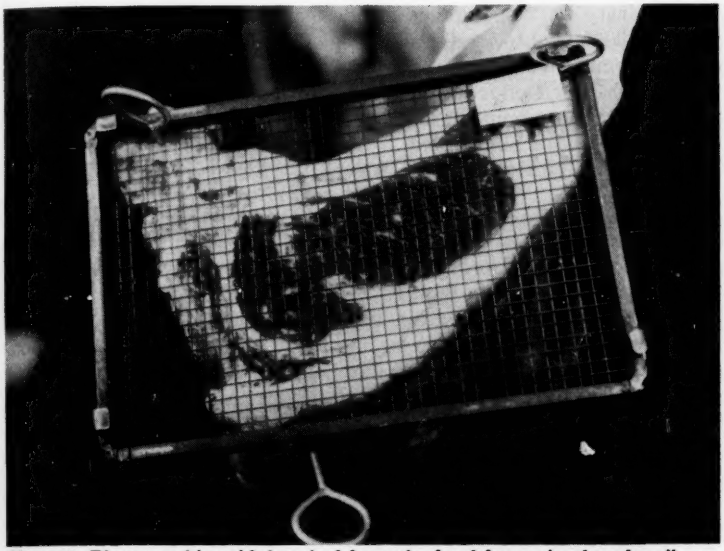

Figure 1. Photographic grid detached from the focal frame, in place for rib eye photo. Note: Animal identification number in upper right hand corner.

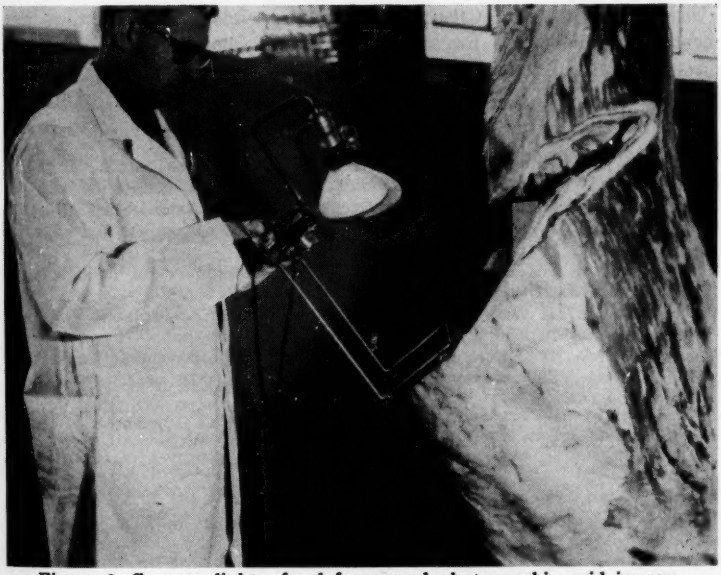

Figure 2. Camera, lights, focal frame and photographic grid in use.

Preliminary work at Laramie has demonstrated that the photographic grid is well adapted to handle lamb loin and rack cuts. Lean-fat ratios are easily determined for these cuts also.

Should the described focal frame be too small or too large for a particular cut there are other frame dimensions and supplemental lens combinations described in Kodak Bulletin No. B-10. A larger frame, for example might be used with wholesale beef cuts.

Summary

A photographic grid technique to be used to measure carcass cuts, especially area of rib eye in beef, is presented. A close-up attachment built according to specifications given in Kodak pamphlet No. B-10 and a newly devised grid attachment for measurement purposes are described.

It is recommended that colored film be used; a method is presented to determine rib eye area from the finished projected 2 x 2 colored slides. The retention of color and the distinctness of the color photographs make it easy to distinguish between lean, fat and bone areas. Quality factors are retained, making possible direct comparisons of individuals between years and between sires. Preliminary data indicate that proportion of lean as determined by photographic grid measurement may have a direct relationship with body composition as determined by specific gravity.

The ease and speed with which the tool can be used has proven to be particularly advantageous while collecting data at custom slaughtering houses. The versatility of the photograpic grid lends itself to the measurement and evaluation of carcass cuts, including wholesale cuts, of all domestic species of farm animals.

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THE CREATININE LEVEL OF BLOOD SERUM AS AN INDICATOR OF CARCASS COMPOSITION [1]

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CURRENT trends in consumer demand emphasize the importance of the relative proportions of fat and lean in the meat-animal carcass. Major differences in carcass meatiness have been shown among cattle considered uniform by the most critical visual appraisal. The development of meat-type cattle would be greatly aided by a practical and accurate *in vivo* determination of carcass composition.

Evidence has been accumulated by Brody (1945) showing that, in general, urinary creatinine reflects the mass of supporting muscle in the body. In a study of the body composition of humans, Miller and Blyth (1952) found that the lean body mass of individuals predicted from creatinine excretion agreed within 13.1% of the determined specific gravity of body fat from body weight in 90% of the cases studied. Creatinine excretion as related to the percentage of separable lean in yearling steers was studied by Lofgreen and Garrett (1954). The percentage of lean was estimated by a densimetric determination of the lean in the 9, 10, 11th rib cut. The correlation between creatinine excretion and percentage of lean was highly significant (r=.67). Creatinine in blood serum was considered as a source of information, since total urine samples are difficult to obtain. Brody (1945) has shown that the quantity of blood varies linearly with body weight. Since creatinine is not re-absorbed in the kidney, the level of creatinine in the blood should reflect the quantity being produced.

Hankins and Howe (1946) have shown that the percentage of separable lean in the carcass can be accurately estimated by the lean in the 9, 10 and 11th rib cut (r=.90). A recent study by Cahill *et al* (1956) has shown a highly significant relationship (r=.85) between the area of rib eye and the edible portion of the carcass.

Experimental

The data reported in this study are from cattle of the University of Wyoming beef herd. Included were 15 bulls and 12 heifers of the 1955 progeny-test cattle as well as 4 fat steers, 3 fat heifers, and 1 cow. Ages ranged from 12 to 14 months on the progeny-test cattle and 19 to 23 on the fat cattle. The cow was 34 months old.

Blood samples were collected one to ten days before slaughter. Blood

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creatinine was determined with modifications of the method of Folin and Wu (1919) where its reaction in a protein free filtrate with alkaline picrate forms a red color (the Jaffe reaction). The Jaffe reaction is not specific for creatinine. Chromogenic material in red blood cells contribute to the formation of red color (Hawk *et al.*, 1951). Preliminary analyses were by the procedure of Hawk *et al.*, using a protein-free filtrate prepared from blood serum in 1/10 dilution and alkaline picrate prepared from saturated picric acid. A Bausch and Lomb monochromatic colorimeter using a 505 mμ filter was used to measure color intensity in terms of percentage of light transmission. The repeatability of early determinations using this method indicated limited precision.

The use of a 1/5 acidic dilution in preparation of protein free filtrate (Mandel and Jones, 1953) and alkaline picrate prepared from 0.26% picric acid (Bausch and Lomb manual, 1950) were found to give more precise measurement with the Bausch and Lomb colorimeter. The technique of measurement is described below.

A standard curve was prepared by obtaining percent transmission readings from known quantities of creatinine. A standard creatinine solution containing 1 mg. creatinine per ml. was used as the source of creatinine. The first dilution (S_1) was made by diluting 2.5 ml. of the standard 25 ml. in a volumetric flask. The second dilution (S_2) was prepared by diluting 5 ml. of S_1 to 100 ml. in a volumetric flask. All dilutions were made with distilled water. The S_2 solution in 0, 1, 2, 3, 4, and 5 ml. quantities was placed in transmission curvettes and filled to 5 ml. with distilled water. The resultant dilutions were 0, 0.1, 0.2, 0.3, 0.4 and 0.5 mg% creatinine (mg. per 100 ml.) respectively. The preparations were run in triplicate on different days.

Alkaline picrate, prepared within 30 minutes of the time of use, consisted of 1 part of 10% sodium hydroxide solution to 5 parts of 0.26% picric acid solution. Two cc. of the alkaline picrate were added to each curvette and allowed to stand for 20 minutes at room temperature. The 0% level or blank was used as the base or 100% transmission level. The percent transmission for each concentration of creatinine was determined from this base, and plotted on semi-logarithmic graph paper for a standard curve.

Protein-free filtrate was prepared according to the technique of Mandel and Jones (1953). Five ml. distilled water were added to 2 ml. of the blood serum to be tested in a 20 ml. centrifuge tube. Two ml. of 2/3 N. sulfuric acid were added slowly and shaken by mechanical shaker for five minutes. After this, 1 ml. of 10% sodium tungstate solution was added and mixed to a homogeneous state by inverting the tube to avoid foam production. Contents were again shaken for five minutes and then centrifuged at 1800 rpm. for 15 minutes.

Five ml. of the resulting clear filtrate were drawn from each tube and placed in curvettes for creatinine reading. Blanks, consisting of 5 ml. dis-

tilled water plus 2 ml. of fresh alkaline picrate, were run in duplicate with each group determination to establish the 100% transmission level. The percent transmission was determined to the nearest 0.2%, 20 minutes after the addition of the alkaline picrate. Creatinine in mg. per 100 ml. was read from the standard curve.

The fat-lean ratio of the 9, 10 and 11th rib cut was measured densimetrically with modifications of the method of Lofgreen and Garrett (1954). The cut was separated from the left side after 10 to 14 days aging by the method of Hankins and Howe (1945). The cut was boned to eliminate errors due to difference in bone development or improper splitting. The weight in air of the boned cut was recorded to the nearest gram. The weight in water was measured by attaching the boned cut to the scale with a piece of fine wire so as to allow it to hang free when submerged in water. Water temperature of 20° C. was used for all determinations. A standard weight of 100 gm. was attached to the wire and weighed under water. This weight, including wire and the submerged standard, was subtracted from each underwater weight as tare. In this manner cuts or samples such as fatty tissue could be weighed under water even though their specific gravities were less than one.

To standardize specific gravity measurements, density determinations were made of tap water at 20° C. Eight replications were made with different volumetric flasks from 10 to 100 cc. The average density (weight in grams/volume in ml.) at 20° C was 0.9957 ± 0.00023.

Specific gravity measurements were made of fat and lean samples of rib cuts. Samples were taken at the same time as boned rib cut densities, 10–14 days after slaughter, and were measured shortly after removal from the cooler at 34° F. (approximately 1° C.). Average specific gravity values of separable fat and lean and of the boned rib cut from which the samples were taken are listed in table 1.

The specific gravity of the boned 9, 10 and 11th rib cut was determined for each carcass. Since the same correction for water density is applicable for the numerator and denominator of the prediction formula below, specific gravity values were used to determine the proportion of fat and lean in the carcass from the formulas:

$$\text{proportion of fat} = \frac{\text{s.g. of lean minus s.g. of whole cut}}{\text{s.g. of lean minus s.g. of fat}}$$

proportion of lean = 1 minus proportion of fat.

Carcass composition was also estimated by rib eye area measured on the left front quarter separated between the 12th and 13th rib from color photographs by the procedure of Schoonover *et al* (1957). The area of external fat was determined by plotting two perpendicular lines at either end of a straight line drawn through the long axis of the longissimus dorsi muscle. The external fat within the boundry of these two perpendicular

TABLE 1. SPECIFIC GRAVITY OF FAT, LEAN AND BONED RIB CUT

	No. samples	Av. specific gravity	Standard error	Av. specific gravity of boned rib cut	Standard error
Fat	23	0.9229	0.0039	1.028	.000055
Lean	16	1.0659	0.0013	1.033	.000072

lines was measured for an estimate of area of fat. The proportion of lean in the rib cut was estimated by the formula:

$$\text{proportion of lean} = \frac{\text{rib eye area}}{\text{rib eye area} + \text{area of external fat}}$$

Results

Creatinine levels ranged from 1.28 to 2.24 mg. per 100 ml. of blood serum. The average level for all cattle was 1.58 mg. Average levels of 1.73, 1.47, and 1.48 were determined for the progeny-test bulls, progeny-test heifers, and older cattle, respectively.

The percentage of lean in the boned 9, 10, and 11th rib cut ranged from 41.7 to 99.4. In both age groups males had a higher percentage of lean than females. The difference is shown by average values of 84.7 and 61.5% lean for bulls and heifers in the progeny-test cattle, and 58.6 and 49.6% lean for steers and heifers in the older cattle. Correlations between the percentage of lean and serum creatinine are presented in table 2.

Difference in fatness within age groups, line and sex was less than the difference between these divisions; thus the highest correlation existed where all variation was considered. Variation in rib-cut composition in females was small, so that the higher correlation existed in males.

Additional carcass data were obtained from photographic measure of rib-eye area on the progeny-test cattle. Rib-eye areas ranged from 4.19 to 9.70 sq. in. A portion of the wide range in rib-eye area can be attributed to variations in carcass weight as shown in table 3.

Regression analysis showed significant increases of 1.27 and 0.40 sq. in.

TABLE 2. CORRELATION BETWEEN LEAN PERCENTAGE AND SERUM CREATININE

Classification	No.	Total	Within age group	Within age, line and sex
All cattle	35	.55**	.54**	.23
Males	19	.55*	.40*	.16
Females	16	.22	.35	.30

* Significant at the 5% level.
** Significant at the 1% level.

TABLE 3. AVERAGE LIVE WEIGHT, CARCASS WEIGHT AND RIB EYE AREA OF PROGENY-TEST CATTLE BY SEX

Sex	No.	Av. age	Av. live wt.	Av. carcass wt.	Av. rib eye area
		mo.	lb.	lb.	sq. in.
Bulls	15	13	652±127.9	370.3±82.7	7.70±1.20
Heifers	12	13	532± 59.1	307.5±43.2	5.16±0.65

of rib-eye area per 100 lb. of carcass weight for bulls and heifers, respectively. The difference in regression values was highly significant. These regression values were used to correct rib-eye area for deviations from average carcass weight in each sex. The correlations between serum creatinine and the corrected and uncorrected rib-eye areas are reported in table 4.

The highest correlation existed between serum creatinine and rib-eye area in heifers. In bulls, the correlation between uncorrected rib-eye area and serum creatinine was negative. However, when the carcass-weight correction was applied and line differences removed, the correlation coefficient was positive and approached significance. Carcass-weight correction and line difference had a lesser effect on the correlation between serum creatinine and rib-eye area in females. This is explained in part by a rather uniform carcass weight and degree of condition in females. A wide range in fatness and carcass weight (table 3) existed in bulls. The largest rib-eye areas were associated with the greatest percentage of fat. A negative correlation between rib-eye area and percentage of lean ($r=-.53$) was found for the 15 bulls on progeny test.

The total relationships between the two estimates of carcass composition studied are of interest. The correlation between the proportion of lean in the 9, 10, and 11th rib cut as determined by specific gravity and the proportion of lean in the rib-eye cut as determined by photographic measurement was highly significant ($r=.94$). These data indicate that the ratio of area of rib eye to total area of rib cut as measured by photographic means may give an accurate estimate of the lean tissue in the carcass.

TABLE 4. CORRELATION BETWEEN RIB EYE AREA AND SERUM CREATININE

Classification	No.	Uncorrected rib eye area	Corrected rib eye area	Corr. rib eye area within sex and line
Progeny test cattle	27	.22	.52**	.45*
Bulls	15	—.16	.00	.44
Heifers	12	.65*	.63*	.51

* Significant at the 5% level.
** Significant at the 1% level.

Summary

Serum levels of creatinine were found to be significantly related to percentage of lean in the boned 9, 10, and 11th rib cut ($r=.55$, $n=35$) and rib-eye area corrected for carcass weight ($r=.52$, $n=27$). Although the above correlations were highly significant, the predictions by serum creatinine were low, $r^2=.27$, and $r^2=.31$. Thus only 27% of the variation of lean of the rib eye as measured by area and 31% of the variation of lean in the boned 9, 10, and 11th rib cut as measured by specific gravity could be accounted for by differences in serum creatinine levels.

The relationships between the estimates of carcass composition were highly significant. The correlation between corrected rib-eye area and percentage of rib-cut lean was .79. The area of external fat and the area of rib-eye measured from colored photographs were used to estimate the proportion of lean. The correlation between this estimate and the proportion of lean in the boned 9, 10, and 11th rib cut determined by specific gravity was .94. The data indicate that this photographic estimate could be used as an accurate estimate of carcass composition.

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THE EFFECT OF PROGESTERONE ON THE ESTROUS RESPONSE OF ESTROGEN-CONDITIONED OVARIECTOMIZED COWS [1]

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IT is generally accepted in the field of mammalian reproduction that estrogens alone are sufficient to induce sexual receptivity in ovariectomized females of several species. The cow is one of the species studied. Asdell *et al.* (1945) were able to bring ovariectomized heifers into heat by administering 0.099 mg. of estradiol benzoate daily for three days. However, in an investigation dealing with the induction of estrus in the ovariectomized guinea pig, Dempsey *et al.* (1936) observed that sexual receptivity could be induced in spayed guinea pigs by injecting progesterone after they had been conditioned with small amounts of estrogen. Similar results have been reported for other species. The synergistic action of progesterone with estrogen has been reported by Boling and Blandau (1939) for the rat, by Ring (1944) for the mouse, and by Frank and Fraps (1945) for the golden hamster. Kent and Liberman (1949) induced psychic estrus in ovariectomized hamsters by injecting progesterone directly in the right lateral ventricle of the brain. It was suggested that progesterone may act directly upon the cranial nuclei by facilitating the manifestation of reflex mating activity. Robinson (1952) induced estrus in ewes by administering progesterone 48 hours before they were injected with PMS.

This investigation deals with the synergistic and antagonistic action of progesterone on the estrous response of estrogen-treated ovariectomized cows. In addition, observations are presented on the synergistic action of desoxycorticosterone acetate (DOCA) and of testosterone propionate (TP).

Experimental Procedure

Seven cows (1 Ayrshire, 1 Brown Swiss, 1 Guernsey, 3 Holsteins, and 1 Jersey) were used as experimental animals. The ages ranged from two to four years and the weights from 725 lb. for one Guernsey to 1300 lb. for the Brown Swiss. Four of the cows had not calved, two had one calf each, and one had calved twice. All animals were considered healthy at the time of this investigation and were checked for the occurrence of normal estrous

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cycles before ovariectomy. The cows were bilaterlly ovariectomized and were not subjected to experimental procedure for at least six to eight weeks following surgery. They were maintained in a lot (15 x 20 yards) and fed a ration consisting of equal parts coarse alfalfa hay and oat straw which was available at all times. Each hormone was injected in a single dose subcutaneously in the neck region. Animals comprising the experimental group were checked for the degree of their estrous response at 3-hour intervals following hormone treatment by observing their behavior in the lot. Furthermore, sexual receptivity in each cow was determined by placing her individually in a small pen (20 x 25 feet) with two or three young bulls. Sexual receptivity was also checked at 3-hour intervals. Four or five bulls were maintained in a pen near the cows for this purpose.

The following system was devised to score the degree of estrous behavior response of the experimental animals: 0, no signs of estrus; +, restless and followed by other cows; ++, mounts and stands for other cows; and +++, accepts bull.

Preliminary experiments indicated considerable variation in the degree of estrous response attained by cows receiving the same quantity of estrogen per unit of body weight. For example, four cows were injected with estrogen at the rate of 0.183 mg. per 1000 lb. body weight and the following results were obtained: An Ayshire (900 lb.) a 0 reaction; a Brown Swiss (1230 lb.) a + reaction; a Holstein (1025 lb.) a ++ reaction; and a Holstein (1165 lb.) a +++ reaction. Asdell *et al.* (1945) observed a similar variability in the response of ovariectomized heifers to estrogen. This variability in the estrous reaction may be due to different thresholds of the nervous system to estrogen rather than differences in body weight.

The minimal amount of estradiol benzoate administered in a single dose which would induce sexual receptivity was determined for each cow. Furthermore, the quantity of this estrogen that would cause an estrous behavior response of + or less was also determined for each animal. This was considered to be the conditioning or priming dose. It was desirable to re-check, at intervals, the behavior response to this level of estrogen. This conditioning dose of estradiol benzoate was employed in the experiments dealing with the synergistic action of progesterone as well as in the desoxycorticosterone acetate and testosterone propionate experiments. In these experiments a ++ or +++ estrous behavior response was considered to be an indication of synergistic action in the estrogen-conditioned cow. However, observations dealing with the antagonistic action of progesterone on estrogen were made on cows which had received a dose of estradiol benzoate which when administered alone would induce sexual receptivity.

Each cow was subjected to one experimental period each week. Animals were allowed to rest for one or two weeks following three or four experimental periods before starting another series of observations.

Results

Data from experiments dealing with the synergistic action of progesterone on a conditioning level of estradiol benzoate in the ovariectomized cow are summarized in table 1. Observation on progesterone-estrogen antagonism in the ovariectomized cow are presented in table 2 and table 3. Data relative to the synergistic action of desoxycorticosterone acetate and testosterone propionate on estrogen are given in table 4.

Discussion

A synergistic action of progesterone was observed in all six cows when 1 mg. of progesterone was administered either with, or 12 hours following,

TABLE 1. ESTROUS BEHAVIOR RESPONSE OF ESTROGEN-CONDITIONED OVARIECTOMIZED COWS TO 1 MG. OF PROGESTERONE [a]

Cow No.	Injection interval between progesterone and estrogen			Interval between injection of estrogen		Duration of estrous behavior	Degree of estrous behavior [b]	Duration of +++ estrous behavior
	before	with	after	onset of estrous behavior	disappearance of estrous behavior			
	hours			hours	hours	hours		hours
J-3818		0		18	52	34	+++	6
			12	18	36	18	+++	6
			24	24	40	16	+++	6
			48	—	—	—	0	
H-3991	12			39	54	15	+++	9
	24			36	51	15	++	
		0		33	45	12	+++	9
			12	24	36	12	+++	9
			24	28	34	6	+++	6
			48	—	—	—	0	
BS-3854	12			39	57	18	+++	6
	24			48	57	9	+	
		0		16	31	15	+++	6
			12	32	48	16	++	
			24	—	—	—	0	
			48	—	—	—	0	
A-3715		0		12	45	23	+++	12
			12	21	45	14	++	
			24	—	—	—	0	
H-3955	12			39	54	15	+++	9
	24			36	51	15	+	
		0		39	48	9	+++	6
			12	30	45	15	+++	6
			24	21	33	12	+++	6
			48	21	42	11	+	
G-3969	12			39	54	15	+++	9
	24			36	51	15	++	
		0		18	45	27	+++	6
			12	39	57	18	+++	6
			24	27	57	30	+++	6
			48	24	54	30	+	

[a] Conditioning dose of 0.2 mg. of estradiol benzoate for all cows except G-3969 which received 0.12 mg.

[b] 0, no signs of estrus; +, restless, followed by other cows; ++, mounts and stands for other cows; +++, accepts bull.

a conditioning dose of estrogen (table 1). A similar response was noted in four cows (J-3818, H-3991, H-3955, G-3969) which received the progesterone 24 hours following estradiol benzoate. However, when the injection interval between the hormones was extended to 48 hours no effect was observed in the five cows on this treatment (J-3818, H-3991, BS-3854, H-3955 and G-3969). In some instances, as indicated in table 1, signs of

TABLE 2. EFFECT OF PROGESTERONE INJECTED WITH 0.4 MG. OF ESTRADIOL BENZOATE ON ESTROUS BEHAVIOR RESPONSE OF OVARIECTOMIZED COWS

Cow No.	Progesterone	Estrogen-progesterone ratio	Interval between injection of hormones and appearance of estrous behavior	Interval between injection of hormones and disappearance of estrous behavior	Degree of estrous behavior [a]	Duration of +++ estrous behavior
	mg.		hours	hours		hours
J-3818	0	0	21	42	+++	18
	60	1:150	—	—	0	
	30	1:75	24	44	+++	9
	15	1:37.5	15	28	+++	9
	5	1:12.5	17	30	+++	9
H-3991	0	0	29	41	+++	6
	30	1:75	—	—	0	
	15	1:37.5	21	51	+++	9
	5	1:12.5	23	29	++	
H-3949	0	0	29	41	+++	
	30	1:75	—	—	0	
	5	1:12.5	28	34	+++	6
BS-3854	0	0	24	35	+++	9
	30	1:75	—	—	0	
	15	1:37.5	21	57	++	
	5	1:12.5	29	40	+++	12

[a] See footnote to table 1.

estrous behavior (+) appeared before the administration of progesterone, particularly if the interval between the estrogen and progesterone was 24 hours or more. Four cows (H-3991, BS-3854, H-3955 and G-3969) were used to study the effect of injecting progesterone prior to estrogen administration on the estrous response. Synergistic action was observed in all four cows when 1 mg. of progesterone was given 12 hours preceeding a conditioning dose of estradiol benzoate. Two cows (H-3991 and G-3969) showed a similar response when the injection interval was 24 hours before estrogen. A swelling of the vulva and the secretion of mucus were observed in all cows showing the synergistic action of progesterone. However, the amount of mucus was somewhat less than would be observed in normal estrus.

In the instances in which cows indicated bull acceptance, (table 1), the

mean interval between estrogen injection and the onset of estrous behavior (latent period) was 28±10 hours[3]; the mean interval between estrogen injection and the disappearance of estrous behavior was 46±9 hours; and the mean duration of estrus was 18±5 hours. The period of sexual receptivity was 7±2 hours. Under the conditions of these experiments, the period of bull acceptance was approximately 39% of the time the cows showed estrous activity. According to Asdell (1946) a compilation of available data for cattle of all ages gives a mean duration of heat as

TABLE 3. EFFECT OF PROGESTERONE ADMINISTERED BEFORE AND AFTER 0.4 MG. OF ESTRADIOL BENZOATE ON ESTROUS BEHAVIOR OF OVARIECTOMIZED COWS

Cow No.	Progesterone		Interval between estrogen injection and appearance of estrous behavior	Interval between estrogen injection and disappearance of estrous behavior	Degree of estrous behavior[a]	Duration of +++ estrous behavior
	12 hours before estrogen	12 hours following estrogen				
	mg.	mg.	hours	hours		hours
BS-3854	60		—	—	0	
	30		—	—	0	
		60	—	—	0	
		30	24	32	+	
H-3991	60		—	—	0	
	30		39	54	+++	6
		60	—	—	0	
		30	19	35	++	
H-3995	60		—	—	0	
	30		51	57	+++	6
		60	—	—	0	
		30	39	54	+++	6

[a] See footnote to table 1.

13.6±3.9 hours. In the case of the four cows treated with progesterone prior to estrogen, the mean interval between estradiol benzoate injection and the appearance of estrous behavior was 39±4 hours. The interval to the disappearance of activity was 54±3 hours.

The data presented in table 1 dealing with the synergistic action of progesterone in estrogen-conditioned ovariectomized cows are in agreement with the findings of Dempsey *et al.* (1936) on the spayed guinea pig and with the results reported for ovariectomized females of other mammalian species. Young (1941) has critically reviewed the literature dealing with the hormonal aspects of mating behavior in female mammals.

The synergistic effect of progesterone may be of physiologic significance in the induction of the normal estrous response in the cow. Progesterone

[3] Mean and standard deviation.

may play a role in the release of luteinizing hormone and subsequent ovulation. Hansel and Trimberger (1952) observed marked structural changes in the granulosa cell layer prior to the rupture of the follicle in the cow. This finding suggests that progesterone may be produced before a corpus luteum is formed. Furthermore, scattered luteal cells in the ovary and the secretory activity of the waning corpus luteum of the

TABLE 4. ESTROUS BEHAVIOR RESPONSE OF ESTROGEN-CONDITIONED OVARIECTOMIZED COWS TO DESOXYCORTICOSTERONE ACETATE (DOCA) AND TESTOSTERONE PROPIONATE (TP) [a]

Cow No.	Hormone		Interval between estrogen injection and onset of estrous behavior	Interval between estrogen injection and disappearance of estrous behavior	Degree of estrous behavior [b]	Duration of +++ estrous behavior
	DOCA	TP				
	mg.	mg.	hours	hours		hours
J-3818	4		39	57	++	
	8		15	45	++	
H-3991	4		24	51	++	
	8		21	39	+++	6
		2	21	51	+++	12
		4	18	42	+++	9
BS-3854	4		39	45	+	
	8		21	42	+	
		2	—	—	0	
		4	21	39	+++	15
A-3715	4		27	57	++	
	8		33	51	+	
		2	42	48	++	
		4	36	57	+++	12
H-3955		2	30	48	+	
		4	27	54	+	
		8	21	45	+++	9

[a] 0.2 mg. of estradiol benzoate 12 hours before DOCA or TP.
[b] See footnote to table 1.

previous cycle may also contribute to the production of this hormone during the period of follicular growth. In the case of a pregnant goat, Raeside and Turner (1955) have reported the presence of progesterone in blood leaving an ovary with only a Graafian follicle as well as in blood from an ovary with a corpus luteum. The presence of progestin in bovine follicular fluid was detected by Duyvené de Wit (1938) using the bitterling test. Hooker and Forbes (1947) have found progesterone in follicular fluid from sow ovaries. Hays (1949) was also able to detect this hormone in follicular fluid from sows with large type cystic ovaries. Hansel and Trimberger (1952) reported subcutaneous injections of 5 to 10 mg. of

progesterone at the beginning of estrus hastened the ovulatory process in dairy heifers. Both the length of estrus and the time from the end of estrus to ovulation were significantly reduced.

An antagonism of progesterone on the action of estrogen was observed in ovariectomized cows as shown in table 2 and table 3. In cow J-3818, an estrogen-progesterone ratio of 1:150 caused an inhibition of estrous response whereas a ratio of 1:75 was effective in blocking estrus in three cows (H-3991, H-3949, and BS-3854, table 2). Cows receiving 15 and 5 mg. of progesterone showed either a ++ or +++ estrous behavior response. A slight indication of mucus production and swelling of the vulva was observed in these cows. No sign of estrus were noted when 60 mg. of progesterone were administered 12 hours before or 12 hours following 0.4 mg. of estradiol benzoate (table 3). However, in two cows, H-3991 and H-3995, ++ or +++ estrous behavior responses were observed when 30 mg. of the hormone were administered 12 hours before or following estrogen. The 30 mg. level of progesterone caused an antagonism in the case of H-3991 when given with estradiol benzoate (table 2). It is possible that the disappearance of estrous behavior in the normal cow before ovulation may be due to the antagonistic action of progesterone.

It is of interest that Raeside and Turner (1951) have found that daily subcutaneous injections of 50 and 75 mg. of progesterone were effective in maintaining pregnancy in dairy heifers following the removal of the corpus luteum in early pregnancy.

Various investigators have studied the effect of progesterone on the female reproductive cycle in different mammalian species. Selye *et al.* (1936) demonstrated that large doses of progesterone inhibited the estrous cycle in the rat. Dutt and Casida (1948) observed a suppression of estrus in ewes injected with 5 or 10 mg. of progesterone starting on the fourth, eighth and twelfth days after the first day of estrus. Ulberg *et al.* (1951) in a study of the ovarian response in heifers to progesterone found that 50 mg. daily inhibited heat and ovulation if treatment started before estrus occurred. These investigators interpreted their data in accord with the theory that progesterone inhibits the action of the gonadotrophin complex, mainly by preventing the luteinizing hormone from acting on the ovary. Nellor and Cole (1956) found in beef heifers that, when the injection of 560 mg. of progesterone was followed 15 days later by a single injection of equine gonadotrophin, 90% came into heat 16–19 days after progesterone treatment. A single or multiple ovulation occurred. However, the conception rate (17%) was low. Trimberger and Hansel (1955) also reported a low conception rate in dairy cattle following estrous control by progesterone.

As shown in table 4, three cows (J-3818, H-3991, and A-3715) showed a synergistic response to desoxycorticosterone acetate. Sexual receptivity was observed in H-3991 after receiving 8 mg. of this hormone. Byrnes and Shipley (1955) have observed a similar response in ovariectomized guinea

pigs. Bull acceptance was observed in four cows (H-3991, BS-3854, A-3715, and H-3955) following treatment with testosterone propionate. The mean duration of sexual receptivity following testosterone propionate was 11 ± 2.5 hours. The secretion of mucus and the response of the vulva were noticeable in all cows receiving DOCA and TP with the exception of BS-3854 which showed no response. Substances such as desocycorticosterone and testosterone may function as progestins or be converted into compounds with such physiologic activity. The similarity in the basic ring structure of progesterone, desocycorticosterone and testosterone and the type of substituents at C_{17} probably account for the common response obtained in the estrogen-conditioned cow. Miller and Turner (1955) demonstrated in the cow that progesterone is converted into substances with marked androgenic activity. These metabolites may be of significance in the induction of mating behavior in the cow. These observations suggest that various steroids may be effective in the mating behavior of the cow. Cole *et al.* (1945) have reported that treatment with testosterone propionate and PMS combined was an effective means of inducing estrus in the ewe. Estrus was manifested by 39 of 48 ewes receiving androgen and PMS together as compared to 24 of 54 receiving only PMS. However, the percentage of fertile matings was apparently reduced by androgen. Robinson (1950) induced estrus without ovulation in ewes treated with 35 mg. of testosterone propionate 24 hours before they received 800 I.U. of PMS.

Summary

Progesterone can induce estrous behavior, including sexual receptivity in the estrogen-conditioned ovariectomized cow. Maximal synergistic action of progesterone was observed when this hormone was injected 12 hours before, simultaneously with, or 12 hours following a conditioning level of estrogen. It is suggested that after conditioning with female sex hormone, normal sexual receptivity in the cow may be caused by the action of progesterone produced during the period of the pre-ovulatory development of the Graafian follicle.

Progesterone in large doses can antagonize the estrous behavior response in ovariectomized cows injected with a level of estrogen which would otherwise induce sexual receptivity. Estrogen-treated cows injected with 30 mg. or more of progesterone failed to show signs of estrus.

Desoxycorticosterone acetate and testosterone propionate both show a synergistic action in estrogen-conditioned ovariectomized cows. Other steroids may be effective in the mating behavior of the cow.

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FACTORS AFFECTING FETAL PIG WEIGHT LATE IN GESTATION [1, 3]

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INTEREST in the factors affecting birth weight grows out of its known association with postnatal viability and rate of gain (Kuhlman, 1928; Vestal, 1936; and others). The maternal contribution to variability in birth weight of the offspring is of greater importance than the paternal contribution in several species of mammals. Wright (1922) estimated that about 75% of the variability in birth weights of guinea pigs is due to maternal factors; in rabbits maternal environment accounts for 25–70% of the variability in birth rates (Venge, 1950). About 7% of the variability in birth weights of pigs is accounted for by sire differences; whereas an estimated 47% of the variation is caused by environment common to litter-mates (Lush *et al.*, 1934).

In the current investigation groups of factors assumed to influence fetus weight late in ingestation—(1) age, weight, and condition of the dam; (2) survival rate and litter size; (3) litter size and number of pigs in a uterine horn; and (4) the intrahorn position of the pigs and number of pigs in a uterine horn—have been studied to determine the relative importance of the components of the group. The degree to which variations in litter size and number of pigs in a uterine horn may act through channels other than variation in membrane weight has also been examined.

Materials and Methods

The unborn litters of the 46 gilts and 34 sows used in this study were from the University of Wisconsin swine breeding research herd maintained in cooperation with the U.S.D.A. Regional Swine Breeding Laboratory. The sires and dams of these litters were of various breeding groups; mating within each dam group was at random to the boards within a particular sire group (table 1). The gilts, all spring born, were bred at their first post-puberal estrus, the breeding season lasting from September 19 to January 11. The sows, all yearlings, had two separate breeding seasons—

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September 21 to November 14 for sows bred to Spotted Poland China boars and November 22 to January 15 for sows bred to Poland China boars.

Gilts were self-fed a balanced concentrate feed [4] on pasture from the time they were weaned until they were bred; at breeding all gilts were changed to a bulkier ration.[5] All sows were hand-fed ear corn on pasture from the time they weaned their previous litters until the breeding period, after which sows bred to Spotted Poland China boars were self-fed a fairly bulky ration.[5] Poland China sows bred to Poland China boars were hand-fed this same ration after November 22; in all cases this bulkier ration was continued until autopsy.

TABLE 1. PARENT GROUPS BY BREEDS AND AGES

	Dam groups						
	Breed of gilt [a, b]				Breed of sow [a, b]		
Breed of sire [b]	DY-YD	PY-YP	DP-PD	P	D	Y	P
SP	(7–9) [c]	(7–12)	(9–21)		(3–9)	(3–6)	(3–5)
P				(2–4)			(3–14)

[a] Gilts were bred to spring boars; sows were bred to yearling boars.
[b] SP, P, D, Y: Spotted Poland China, Poland China, Duroc, and Yorkshire, respectively. DY-YD, etc.: Reciprocal crosses between the two breeds indicated.
[c] First no.: number of sires; second no.: number of dams.

Generally, the autopsy procedure was as follows: animals were slaughtered at 7-day intervals; all animals that had reached 102 to 108 days of gestation within each week were slaughtered at that time. One measurement of backfat thickness—1.5 to 2.5 in. off the midline at the level of the seventh rib—was taken on each sow and gilt before slaughter and the weight of the hot, packer-style carcass was obtained. Reproductive organs anterior to the middle of the cervix were removed when the carcass was opened, and the uterus, ovaries, etc. were so handled as to prevent drying before examination was completed. The ovaries were removed and corpus luteum counts were made. The broad ligament and cervix were separated from the intact uterine horns; then, starting at the tip of one horn, the individual fetuses and their membranes were removed, separated, and weighed, sex and position in the horn being recorded. The second horn was then handled similarly.

The first step in the analysis of the data was to adjust the weights of the normal fetuses (showing no gross postmortem changes or anatomical abnormalities) to that of a male fetus of the average age of approximately

[4] 980 lb. corn
710 lb. oats
150 lb. wheat
140 lb. soybean oil meal
60 lb. meat scraps
20 lb. limestone
10 lb. mineralized salt
5 lb. antibiotic mixture

[5] 600 lb. corn
600 lb. oats
600 lb. 13% alfalfa leaf meal
100 lb. meat scraps
100 lb. soybean oil meal
10 lb. mineralized salt

TABLE 2. THE RELATIONSHIP OF FETUS WEIGHT TO FETUS AGE (102–108 DAYS OF GESTATION) WITHIN SEX OF FETUS AND PARITY GROUP OF DAM

(Based on Unweighted Litter Averages)

Parity group of dam	Sex of fetus	Number of litters	Average fetus wt.	(Weight on age)
			gm.	
Gilts	male	46	946.0	16.04
	female	43	910.0	19.85
Sows	male	34	1026.7	34.37
	female	34	1010.4	34.97

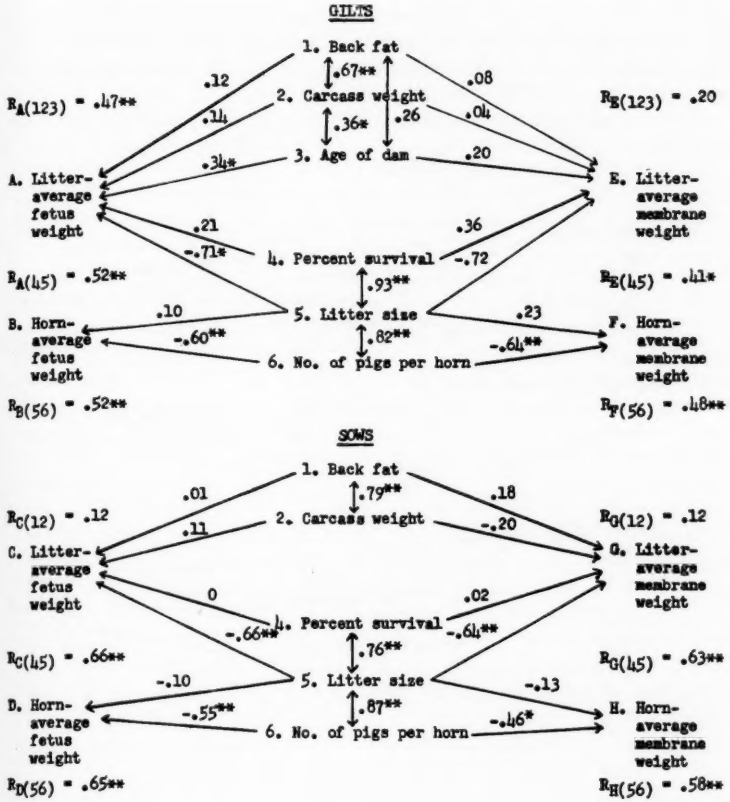
105 days. All other analyses involving fetus weight were based on the adjusted values. The adjustment to standard age was made for each parity group of dam by using the linear regression of weight on age within sex (table 2); the adjustment for sex was then made on the basis of the average weight difference between the sexes. Membrane weights were not adjusted as no difference due to sex or increase due to age of fetus was apparent. Absence of an increase in membrane weight in late gestation is in accordance with the data presented by Warwick (1928) for swine, Ibsen (1928) for guinea pigs, and Hammond (1935) for rabbits. The means and standard deviations for the various factors studied are given in table 3.

Each simple correlation used in the calculation of the standard partial regression coefficients (figures 1 and 2) was calculated from pooled within-dam-breeding group sums of squares and cross products. Tests for hetero-

TABLE 3. THE MEANS AND STANDARD DEVIATIONS BY PARITY GROUP OF DAM FOR THE VARIOUS FACTORS STUDIED

Item	Gilts		Sows	
	Means [a]	S.D.[b]	Means [a]	S.D.[b]
Litter av. fetus wt. (gm.) [c]	966.9	142.1	1025.6	165.8
Horn av. fetus wt. (gm.) [c]	971.7	153.8	1031.7	175.0
Litter av. membrane wt. (gm.)	239.1	38.9	254.7	51.0
Horn av. membrane wt. (gm.)	241.0	45.5	256.4	58.9
Litter size	7.4	2.8	10.6	3.1
No. of pigs per horn	3.8	1.5	5.3	1.7
Percent survival	61.7	23.8	64.9	19.9
Ovulation rate	12.2	1.9	16.4	3.0
Age at slaughter (days)	346.7	24.1	—	—
Carcass wt. (lb.)	232.7	39.6	374.0	54.8
Backfat thickness (in.)	2.0	0.4	2.8	0.5

[a] Unweighted breeding group averages.
[b] Based on the average within-breeding-group mean square.
[c] Adjusted for sex and age.



* $P < 0.05$
** $P < 0.01$

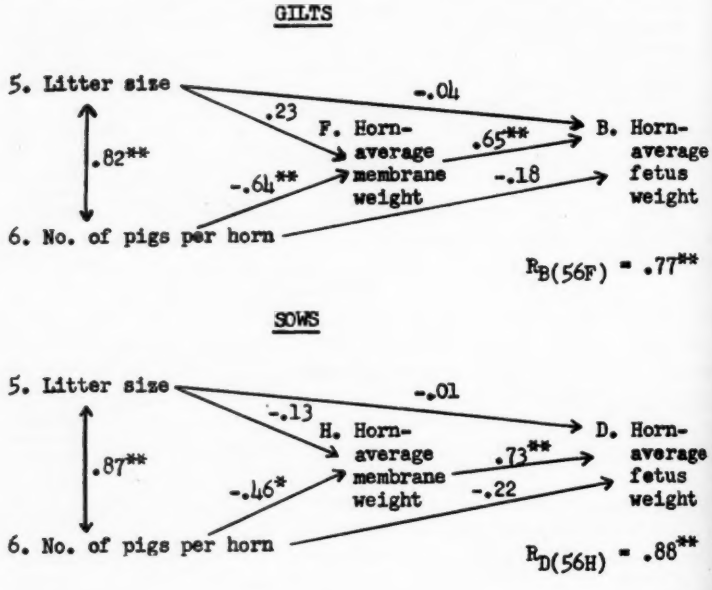
Figure 1. Factors affecting average fetus and membrane weights at 105 days of gestation.

geneity of simple regressions within parity groups indicated no significant differences among the different groups for any of the factors studied (Snedecor, 1953).

The numbers accompanying the unidirectional arrows in figures 1 and 2 are standard partial regressions or path coefficients; when referred to in the text they are symbolized as follows: $P_{A1:23}$ indicates the path from 1 (back-fat) to A (litter average fetus weight) and shows the direct effect of variation in 1 on the variability of A while holding constant the direct

effect of 2 and 3 on A. The figures accompanying the bidirectional arrows are simple correlation coefficients. $R_{A(123)}$ is the multiple correlation coefficient measuring the association between A and the three independent variables—1, 2, and 3.

Tests of significance involving path coefficients utilized the standard



* $P < 0.05$
** $P < 0.01$

Figure 2. The relationship of litter size and number of pigs per uterine horn to horn average fetus and membrane weights at 105 days of gestation.

errors of these coefficients calculated by applying Brandt's (1928) method for the standard errors of net partial regression coefficients when three independent variables were involved and by Wright's (1934) method when only two independent variables were involved.

Results and Discussion

A part of the litter differences in the birth weights of pigs has commonly been ascribed to variations in age of the dam and to related factors such as her weight and fatness. For the gilts in the present study the multiple

correlation of litter average fetus weight at 105 days of gestation with age of dam, carcass weight, and back-fat thickness, was 0.47 (figure 1). The standard partial regression of fetus weight on age of dam (0.34) was significant; whereas the regressions of fetus weight on carcass weight and on fatness of the dam were not. The exact ages of the sows were not known; therefore, only the weight and fatness of these animals were considered in this part of the analysis. The multiple correlation of these factors with fetus weight in sows was 0.12 (for $P<0.05$, $R=0.43$). (The comparable multiple correlation in gilts—fetus weight with back-fat and carcass weight —is 0.35; for $P<0.05$, $R=0.37$.)

Litter size and percent survival together were significantly correlated with litter average fetus weight in gilts ($R_{A(45)}=0.52$) and in sows ($R_{C(45)}=0.66$). The path coefficients for fetal survival, however, were negligible ($P_{A4:5}=0.21$ for gilts; $P_{C4:5}=0.00$ for sows). Thus there is no evidence to indicate that factors decreasing fetal survival, within the limits of the feeding and management conditions studied, depress the weights of the remaining fetuses or that the decomposition products from increased proportions of degenerate fetuses retard the growth of the survivors.

A further breakdown of the effect of the number of fetuses on their average weight was accomplished by comparing the direct effect of the number of fetuses in a uterine horn with that of the total number of fetuses in the litter. Thus a comparison can be made of the effects of competition for space in the horn and its nutrient supply with the effects of more general competition for space within the dam's body and for nutrients from the general nutrient pool. Factors local to the horn (number of fetuses per horn) were found to be of more importance in determining fetus weight ($P_{B6:5}=-0.60$ for gilts and $P_{D6:5}=-0.55$ for sows) than general factors as measured by number of pigs in the litter ($P_{B5:6}=0.10$ for gilts and $P_{D5:6}=-0.10$ for sows). Increasing the number of fetuses within a uterine horn leads to a decrease in their average weight; however, there is no definite evidence to indicate that variation in litter size has any effect on fetus weight other than that exerted indirectly—correlated variation in litter size and number of fetuses per horn. Eckstein and McKeown (1955) have indicated that in guinea pigs fetus weight is affected by both litter size and the distribution of fetuses between the two uterine horns. Their data and those of Ibsen (1928) indicate that the ratio of the direct effect of litter size on average fetus weight per horn to its indirect effect through correlated variation with number of fetuses per horn is approximately 20 times such a ratio in swine. Their data also show that a negative association exists between the number of fetuses in the two uterine horns; this arises because of the negative correlation between the number of ova released by the two ovaries (Eckstein and McKeown, 1955), with an anatomical barrier preventing transuterine ova migration (Kelly, 1928). This negative association between numbers of fetuses in the two horns has

TABLE 4. AVERAGE FETUS WEIGHT AND MEMBRANE WEIGHT BY POSITION IN THE UTERINE HORN

(Classified by Number of Fetuses per Horn)

Number fetuses per horn	No. of horns	Fetus weight in grams								Membrane weight in grams							
		Position [a]								Position [a]							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Gilts:																	
2	11	1057	1058							236	295						
3	16	977	1047	961						221	241	295					
4	28	998	993	937	973					227	236	214	270				
5	14	948	909	871	854	905				212	202	212	192	240			
6	12	921	813	841	806	744	874			209	194	197	180	179	205		
Sows:																	
2	3	1411	1378							373	392						
3	10	1131	1156	1183						274	324	330					
4	13	1074	1068	1050	1075					252	277	276	301				
5	14	1034	1007	1016	961	1124				234	252	254	229	308			
6	13	946	920	876	909	856	1057			247	216	211	235	219	287		
7	7	1103	1032	951	899	899	910	1039		240	246	236	236	225	219	315	
8	4	1006	976	854	815	904	605	859	950	255	230	222	191	201	174	204	229

[a] The ordinal positions are numbered beginning at the ovarian end.

been interpreted as decreasing the correlation between the number of fetuses in the horn and litter size as compared to a positive correlation between the numbers of fetuses in the two horns, such as exists in swine (0.48 in gilts and 0.55 in sows).

One aspect of the conditions specific to the individual fetus was studied by analyzing the variability due to ordinal position within a uterine horn (tables 4 and 5). A preliminary analysis indicated a significant variation in fetus weight with position for sows and an apparently similar but not significant trend in gilts. It was found that the quadratic regression of fetus weight on position accounted for a significant amount of variation in fetus weight in horns containing three or more fetuses in both sows and gilts. No evidence was found that the quadratic regression coefficients were heterogeneous over the various numbers of fetuses per horn, and it was apparent that fetuses toward the extremes were larger than those toward

TABLE 5. ANALYSIS OF THE EFFECT OF POSITION WITHIN A UTERINE HORN ON INDIVIDUAL FETUS WEIGHTS

	Gilts		Sows	
Source of variation	d.f.	M.S.	d.f.	M.S.
Position: Linear regr., within numbers per horn	5	18640	7	27285
Position: Quadratic regr., overall	1	92606*	1	609137**
Position: Quad. regr. x numbers per horn	3	40696	5	7657
Position: Deviations from regression	6	19992	15	28836
(H x P), within numbers per horn	228	20166	225	27501

* $P<0.05$, ** $P<0.01$.

the middle. This agrees with the observations of Ibsen (1928) in guinea pigs.

Inasmuch as the fetal membranes play an important role in mediating the effects of environmental factors on fetus weight (Barcroft, 1944), attention was given to the degree to which these extraembryonic tissues are in themselves affected by the same environmental factors. As can be seen from figure 1, fetal membranes are generally affected in the same manner and to about the same degree by each group of factors and its components as are the fetuses themselves. Also, intrahorn position has a highly significant effect on membrane weight, the membrane at the cervical end tending to be the largest (table 4).

If the assumption is made that litter size and number of fetuses per horn affect fetal growth by way of membrane development to the full extent of their association with membrane weight, there arises the question as to whether additional direct effects may be demonstrable. The data of Eckstein *et al.* (1955) suggest that, at 65 days of gestation, guinea pig fetus weight reflects both general and local effects (litter size and number of fetuses per horn, respectively) independently of the effect of placenta

weight. In the groups of swine in the present study this relationship is not statistically evident for litter size (figure 2); the direct effect of litter size is negligible ($P_{B5:F6}$=—0.04 for gilts and $P_{D5:H6}$=—0.01 for sows). While most of the influence of number of pigs per horn on fetus weight is mediated by membrane weight ($P_{F6:5} \cdot P_{BF:56}$=—0.42 for gilts and $P_{H6:5} \cdot P_{DH:56}$=—0.34 for sows), the direct effect of this factor on fetus weight, though not statistically significant in either group of animals alone, probably should be given some consideration because of the consistency and size of the paths in the two groups of data ($P_{B6:F5}$=—0.18 for gilts and $P_{D6:H5}$=—0.22 for sows).

TABLE 6. ANALYSIS OF THE EFFECT OF POSITION WITHIN A UTERINE HORN ON INDIVIDUAL MEMBRANE WEIGHTS

	Gilts		Sows	
Source of variation	d.f.	M.S.	d.f.	M.S.
Position: Linear regr., within numbers per horn	5	16566**	7	10605**
Position: Quadratic regr., overall	1	20044**	1	58976**
Position: Quad. regr. x numbers per horn	3	3461	5	2390
Position: Deviations from regression	6	4635	15	3999
(H x P), within numbers per horn	228	2669	225	3531

** $P<0.01$.

The conclusions that might be drawn from the relationship of fetus weight to such factors as position within the uterine horn, the number of fetuses per horn, and membrane weight are that the fetuses having the best uterine vascular contact, the well-developed membranes necessary for the efficient utilization of this contact, and the least space restrictions will be the largest after 105 days of prenatal development.

Summary

Eighty litters of 102–108 day-old fetuses from 46 gilts and 34 yearling sows were used in this study.

In gilts, age of dam appears to be responsible for a greater part of the variability in fetus weight than dam's carcass weight or back-fat thickness. In sows carcass weight and back-fat thickness did not account for a significant variation in fetus or membrane weight; age was not studied.

Survival rate, holding litter size constant, did not have a significant effect on fetus or membrane weight in either sows or gilts; litter size had a marked negative effect. There is no definite evidence to indicate that variation in litter size has any effect on fetus weight independent of its association with the number of pigs in a horn. In both parity groups little of that variability in fetus weight caused by variability in litter size and

number of pigs per horn was brought about independently of variability in membrane weight.

In both parity groups the fetuses and membranes at the extremes of a uterine horn are larger than those toward the middle, the association being described by a quadratic regression. This quadratic regression coefficient does not change significantly with variation in numbers of fetuses per horn.

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THE MAINTENANCE OF EARLY PREGNANCY IN THE OVARIECTOMIZED EWE BY INJECTION OF OVARIAN HORMONES [1]

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EXPERIMENTAL evidence has shown that early embryonic death is an important factor in low breeding efficiency of sheep (Dutt, 1951); also, the greatest incidence of this loss appears to be during the first 18 days of pregnancy (Hulet *et al.*, 1956). Endocrine aberrations such as progesterone or estrogen deficiencies or imbalances theoretically may be considered as potential causes of the early embryonic loss. One approach to the problem is to determine a combination of levels of these hormones that will maintain early pregnancy in ovariectomized animals. Such a treatment could then be used in analyzing the lowered breeding efficiency which might be produced experimentally (e.g. by feeding, breeding or management) to determine if the cause is of this endocrine nature.

Materials and Methods

Studies were made on 48 ewes in 1955–56 and on 19 ewes in 1956–57. Both fine wool and medium wool ewes and rams were used the first year but only fine wool the second year.

The sheep were maintained on mixed hay *ad libitum* and approximately ¾ lb. of grain a head daily.

The ewes ran with painted vasectomized rams and were checked for heat twice daily. Twelve hours after being observed in heat each ewe was hand bred to a fertile ram and assigned to a treated or untreated group. All treated ewes were given an initial hormone injection 48 hours after breeding and were bilaterally ovariectomized 84 hours after breeding. Subcutaneous hormone injections were continued daily until the ewes were slaughtered 25 days after the beginning of estrus and examined for pregnancy. The hormones were dissolved in corn oil for injection. No operation was performed on the untreated ewes.

The study in 1955–56 included Trial A with 37 ewes assigned at random to each of 4 treated groups of 7 and one untreated group of nine. These were run on experiment during the interval from November 15, 1955 to January 8, 1956. One treated group received daily injections of 1 mg. of progesterone and 0.01 mg. of estradiol per 5 lb. body weight. Another group received twice this dosage. One of the remaining treated

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groups received daily injections of 1 mg. of progesterone only per 5 lb. body weight and the other was given twice this dosage.

The remaining 11 ewes in 1955–56 were run in Trial B from January 5 to March 2, 1956 beginning immediately after Trial A. These animals received 1 mg. progesterone and 0.25 mcg. of estrone daily per 5 lb. body weight.

Trial C was run the next breeding season beginning October 8, 1956 and continuing until December 9, 1956. Ten treated and nine untreated ewes were studied concurrently. The treated ewes received the same hormone treatment as those of Trial B, 1 mg. of progesterone and 0.25 mcg. of estrone daily per 5 lb. body weight.

TABLE 1. EWES PREGNANT AT 25 DAYS

Trial	Daily hormone dosage/5 lb. body wt.		No. of ewes	No. preg. at 25 days
	Progesterone	Estrogen		
A[a]	1 mg.	.01 mg. estradiol	7	0
A	2 mg.	.02 mg. estradiol	7	0
A	1 mg.	0	7	2
A	2 mg.	0	7	2
A	0	0	9	6
B[a]	1 mg.	.25 mcg. estrone	11	7[c]
C[b]	1 mg.	.25 mcg. estrone	10	7
C	0	0	9	8

[a] Trial A preceded Trial B in the 1955–56 breeding season.
[b] Both groups of Trial C were run concurrently during the 1956–57 breeding season.
[c] One embryo appeared abnormal, possibly a case of incomplete separation of identical twins. Whether this condition was influenced by treatment is not known. This embryo was not used in the embryo weight study.

Results and Discussion

The number of ewes in the treated and untreated groups and the number pregnant at 25 days are indicated in table 1.

All ewes receiving progesterone and estradiol failed to maintain pregnancy. The results for the ewes receiving progesterone only were also unsatisfactory; four of 14 ewes produced four embryos. Six of nine untreated ewes of Trial A produced nine embryos.

Failure of the ewes receiving estradiol may have been due to an improper progesterone-estrogen ratio. Lyons (1943) reported success in pregnancy maintenance in ovariectomized rats by administration of 4 mg. of progesterone and 1 mcg. of estrone. Estrone, a weaker estrogenic agent than estradiol was used with progesterone in this ratio, therefore, for the subsequent treatments of the ewes.

Seven out of the 11 ewes on Trial B which received 1 mg. of progesterone and 0.25 mcg. of estrone daily per 5 lb. body weight maintained pregnancy. This hormone combination and dosage was considered mod-

erately satisfactory for maintenance of early pregnancy in the ovariectomized ewe.

A study of the embryo weights was made to determine whether there was an effect of treatment on embryonic development. A comparison was made of the embryos from these treated ewes with those from the untreated animals of the same general group but which were run in Trial A immediately ahead of this trial (table 2). A comparison first was made between single and twin embryo weights in the untreated group. No difference was found and all "untreated" embryo weights were compared to "progesterone-estrone" embryo weights by analysis of variance. Embryos from the treated ewes were found to be significantly heavier than those from the untreated ($P<0.01$).

TABLE 2. WEIGHTS OF EMBRYOS MAINTAINED TO 25 DAYS

Year	Group [a]	Single embryos (Weight in mg.) No.	Range	Average	Twin embryos (Weight in mg.) No.	Range	Average
1955–56	Untreated	3	112–145	132	6	122–164	143
	Treated	6	142–202	174	0	—	—
1956–57	Untreated	7	53–146	122	2	66–92	79
	Treated	7	106–208	158	0	—	—

[a] The within-group standard deviations for the 1955–56 and 1956–57 embryo weights were 19.4 and 35.5 respectively.

The finding of heavier embryos from the treated ewes was unexpected and another test of this observation was made in the 1956–57 breeding season on a more homogenous group of ewes. Treated and untreated ewes were run on experiment concurrently. The treated ewes received the same progesterone-estrone dosage as those of Trial B and seven of 10 produced 7 embryos. Eight of 9 untreated ewes of this trial produced 9 embryos. The same comparison of embryo weights was made as before (table 2) and embryos from treated ewes were again significantly heavier than from untreated ($P<0.05$).

The cause of this difference in embryo weight is presumed to be something in the nutritional state of the embryo. It is possible that treatment caused increased nourishment of the embryo at an early stage, possibly by early placentation. (Canivenc *et al.*, 1953, found early implantation in lactating rats given progesterone locally in the uterine wall). Also treatment may have established a more efficient placental mechanism at the usual time and this in turn resulted in improved embryo growth.

Summary

Studies were made on the maintenance of early pregnancy in the ewe by means of hormone injections; a total of 67 treated and control ewes were autopsied 25 days after breeding. Treated ewes were ovariectomized 84 hours after breeding and given daily hormone injections until autopsy. Progesterone and estradiol in the ratio of 100 to 1 were administered to 14 ewes but pregnancy was maintained in none. Fourteen other ewes were given the same dosages of progesterone only and pregnancy was maintained in four. Fourteen of 21 ewes given 1 mg. progesterone and 0.25 mcg. estrone daily per 5 lb. body weight were pregnant at autopsy as compared to 14 of 18 untreated and unoperated ewes.

Embryos from ewes receiving progesterone and estrone were significantly heavier than those from untreated ewes (166 mg. av. as compared to 126 mg.).

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MULTIPLE BIRTH AND SEX RATIO IN RAHMANI SHEEP

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EFFECTIVE selection and efficient breeding programs require estimates of the amount of genetic variabilitity and of the measurable environmental factors affecting the character concerned. In the sheep breeding business the number of lambs born per ewe is of great economic importance, especially among Egyptian fat-tailed sheep where the amount of wool is small and the quality is poor. Several non-genetic factors affect this character in variable degrees (Johansson and Hansson, 1943; Desai and Winters, 1951a; Regab and Asker, 1954). The purpose of the present paper was to study the effect of some of these factors on lambing percentage in a flock of Rahmani sheep and to estimate the repeatability and heritability of this character. The sex ratio among the lambs born in the flock was calculated.

The Data

The records studied were those of ewes kept on the Experimental Farm of the College of Agriculture, University of Alexandria from 1943 to 1955. There were two lambing seasons in the flock. Most lambings occurred during the months, September to February, and they will be referred to as winter lambings. The rest were born during the months, March to August, and they will be referred to as summer lambings. About 9% of all lambings were by ewes lambing twice in a year. Such ewes were not included in the analysis.

The sheep were fed on Barseem (Trifolium Alexandrinum), a legume pasture, from November until May. In the summer they grazed in the fields on waste feeds and were given about ¾ kg. concentrates per head. The concentrates consisted usually of one part undecorticated cotton seed cake to one part rice bran.

Results

The average lambing percentage was 124.0 based on 997 lambings with 1236 lambs out of 279 ewes. The average number of lambings per ewe was 3.56.

Year. Table 1 presents the different lambing percentages for the years 1943 to 1955. They ranged from 108.3 to 139.0 and differences among them were statistically highly significant. They mainly reflect differences in feeding, management and health conditions in the flock. They also

TABLE 1. EFFECT OF YEAR ON LAMBING PERCENTAGE

Year	No. of lambs	Lambing %	Year	No. of lambs	Lambing %
1943	62	114.8	1950	68	119.3
1944	93	119.2	1951	91	128.2
1945	93	124.0	1952	111	127.6
1946	75	121.0	1953	133	138.5
1947	56	127.3	1954	84	127.3
1948	39	108.3	1955	77	128.3
1949	57	139.0			

represent variations in the genetic composition of the flock since rams and sometimes ewes were added to the flock occasionally.

Season of lambing. Fat tailed-sheep seems to have no restricted season for ovarian activity (Hafez, 1953). For practical reasons lambings were arranged to occur in two seasons during the year as mentioned earlier. The winter season included 63.4% of all lambings, with 86.0% of them occurring in the months of October, November and December. The summer season included 36.6% of all lambings, with 79.2% of them occurring in the months of March, April and May.

The lambing percentage and number of lambs born each month, over all years, are given in table 2. The lambing percentage of the summer season was 128.8 and that of the winter season was 121.4 but the difference was not statistically significant.

The highest lambing percentages were those in the middle of the summer season. They represent ewes bred in November and December and lambing in April and May. Good feeding conditions usually prevail during this period. Johansson and Hansson (1943) reported that matings in the middle of the season produced the largest litters in the Shropshire and Cheviot breeds. Ragab and Asker (1954) found that the highest percentage of lambing occurred during the first half of the lambing season (all lambs were winter born).

TABLE 2. EFFECT OF SEASON ON LAMBING PERCENTAGE

Summer			Winter		
Month	Total lambs born	Lambing %	Month	Total lambs born	Lambing %
March	137	126.9	Sept.	24	—
April	95	139.7	Oct.	126	124.8
May	126	131.3	Nov.	316	119.7
June	80	119.4	Dec.	232	125.4
July	10	—	Jan.	67	117.5
Aug.	4	—	Feb.	19	—
All	452	128.8	All	784	121.4

Age of dam. The majority of the ewes had their first lambing when they were about two years old. The number of lambs per birth for ewes of different ages, ranging from 2 to 7 years, are presented in table 3. They increased with the advance of age up to the fifth or the seventh year, and differences among them were statistically highly significant.

Johansson and Hansson (1943), Desai and Winters (1951a), Terrill (1952), Regab and Asker (1954) and Rendel (1956) found that the lambing percentage increased with age and that the maximum was reached when the ewes were 5 to 8 years old depending on the breed.

Table 3 also shows that the coefficients of variability were relatively constant while the means were increasing suggesting that multiplicative effects were important in number of lambs per birth.

TABLE 3. EFFECT OF AGE OF DAM ON NUMBER OF LAMBS PER BIRTH

Age in years	2	3	4	5	6	7
No. of lambs	311	263	205	149	92	54
No. of births	279	207	152	106	68	37
Lambs per birth	1.115	1.271	1.349	1.406	1.353	1.459
Variance	.1019	.1983	.2286	.2434	.2313	.2753
Standard dev.	.319	.445	.478	.493	.481	.525
C.V.	28.6	35.0	35.4	35.1	35.5	36.0

In order to find out if the differences attributed to age of dam were not caused by selection, two tests, used previously by Rendel in 1956, were applied. First by comparing the number of lambs per birth at different ages for ewes with complete lambing records between 2 to 6 years of age with those of all ewes at corresponding ages. The average numbers for the selected ewes were; 1.015, 1.176, 1.279 and 1.294 at 2, 3, 4 and 5 years of age, respectively. They were all smaller than the corresponding averages of all ewes given in table 3 but the differences were not statistically significant. Second, by comparing the lambing results of the culled ewes with those of the selected ones at different ages. The results are shown in table 4. Culled ewes had higher averages than the selected ones at all ages, except the group at 6 years of age. Differences were not statistically significant. The results of the two previous tests show that no effective selection in favor of ewes lambing twins was practiced. In fact there was a tendency for ewes leaving the flock at different ages to have higher lambing percentages than those staying at each age.

Type of birth of dam. Twin born ewes had higher lambing percentages than single born ewes (table 5), but the differences were statistically insignificant. Desai and Winters (1951a) reported that twin born ewes were consistently larger in number at different ages and gave .12 more lambs than single born ewes. In a flock of Ossimi sheep Ragab and Asker (1954)

TABLE 4. NUMBER OF LAMBS PER BIRTH AMONG CULLED AND SELECTED EWES AT THE SAME AGE

Age in years	Culled ewes		Selected ewes	
	No. of births	Lambs per birth	No. of births	Lambs per birth
2	22	1.318	257	1.093
3	25	1.480	182	1.242
4	24	1.500	128	1.273
5	32	1.625	74	1.311
6	31	1.290	37	1.405
7	15	1.467	22	1.455
All	149	1.450	700	1.217

found that lambings percentage among twin born ewes was insignificantly higher than that of single born ones.

Repeatability. Smirnov (1935) reported that prolificacy in the Romanov sheep appeared to be an individual genetic character. Ewes having singles, twins or triplets at their first lambings had averages of 1.89, 2.15 and 2.65 for number of lambs per birth at subsequent lambings.

In the present study the twin born and the single born ewes were classified according to whether they had singles or twins in their first lambing. The resulting four groups of ewes and their lambing results from 3 to 7 years of age, are given in table 6. Differences between the averages were not statistically significant. Ewes giving twins at their first lambing tended to have higher lambing percentages in their subsequent lambings, regardless of whether they were born twins or singles.

The correlation between any two lambing records made by the same ewe was measured by calculating the intra-class correlation for ewes with 4 lambings from 2 to 7 years of age. The estimate was $.056 \pm .041$ based on

TABLE 5. RELATION OF LAMB PRODUCTION TO SINGLE OR TWIN BIRTH OF DAM

Age in years	Ewes born singles		Ewes born twins	
	No. of births	Lambs per birth	No. of births	Lambs per birth
2	220	1.104	59	1.153
3	170	1.265	37	1.298
4	130	1.339	22	1.410
5	90	1.411	16	1.375
6	61	1.295	7	1.857
7	25	1.457	2	1.500
All	706	1.259	143	1.294

123 ewes. The correlation between the first and second lambing was .046±.067. Both estimates were statistically insignificant. It seems that the repeatability of number of lambs per birth in this flock was rather low. When the average of the first and second lambings was correlated with the average of the third and fourth lambings the repeatability was increased to .215±.086. It was statistically significant. Johansson and Hansson (1943) estimated the intra-ewe correlation of .183 for litter size; the correlation of the lambings at the second and third years of age was .164, and the correlation of the average number of lambs per birth at 2–3 and 4–5 years of age of the ewe was .256. Desai and Winters (1951b) reported a repeatability of .0498±.0263 for lambing average using the

TABLE 6. RELATION OF LAMB PRODUCTION THE FIRST LAMBING TO LAMB PRODUCTION FROM 3 TO 7 YEARS OF AGE

Type of ewes lambing	Type of first lambing	No. of births	Lambing % 3 to 7 years
Born twins	Twin	14	142.9
	Single	70	138.6
Born singles	Twin	21	138.1
	Single	465	132.7

intra-class correlation method. Rendel (1956) estimated the repeatability of .094 within breed and herd.

Heritability. The regression of type of birth of the offspring on that of the dam was .04 based on 849 dam-off spring pairs. The estimate was not statistically significant. The heritability of twinning would be .08, *i.e.*, double the regression. This is likely to be biased since no correction was made for non-genetic factors affecting the character. Johansson and Hansson (1943) got an average heritability estimate of .214 using the daughter-dam regression based on three lambings, and .196 using the half-sib correlation, based on two lambings. Desai and Winters (1951b) estimated the heritability of .0736±.0152 using the intra-sire regression of lambing records of offsprings on those of dams. Ragab and Asker (1954) reported a heritability of .0362. Rendel (1956) gave an average heritability of .113. Sidwell (1956), using the correlation between type of birth of the dam and her offspring, found that the heritability was .22 and .12 for mature crossbred and Navajo ewes, respectively.

Sex ratio. There were 1109 lambs available for calculating the sex ratio at birth *i.e.* secondary sex ratio. Male lambs were 535 or 48.2% and female lambs were 574 or 51.8%. Most sex ratios reported previously were about 49% males and 51% females. Chapman and Lush (1932) and Johansson and Hansson (1943) gave estimates of 48.4 and 49.6, respectively, for percent males. Males among the single born lambs were 46.7% and among

the twin born lambs were 51.6%. These two percentages were 47.7% and 49.6% as found by Chapman and Lush (1932) and 50.0% and 49.4% as found by Johansson and Hansson (1943).

Discussion

Ewes giving birth to twin lambs, wean more pounds of lamb than ewes giving singles (Johansson and Hansson, 1943; Terrill, 1952; Sidwell, 1956). The breeders income should increase accordingly. The frequency of ewes giving twins in the flock can be increased when the important environmental factors affecting multiple birth are known and accounted for. Such effects tend to confuse the breeder when selecting ewes with high producing abilities.

The lambing percentage in the flock differed significantly from year to year. Summer lambings had more twin births than the winter lambings although the difference was not statistically significant. Feeding conditions during the mating season and gestation period, for ewes lambing in the summer were better than those available for ewes lambing in the winter. Flushing is known to increase the incidence of multiple birth among ewes (Marshall and Potts, 1921; Darlow, 1942; Terrill and Stoehr, 1942; Johansson and Hansson, 1943). Summer born lambs were also heavier at birth and had lower mortality rates (Karam, 1956). Until summer pastures or dry lot feeds are available at economical prices for summer born lambs and the lactating ewes, winter lambing will remain the common practice in Egypt.

The possibility of having two lamb crops each year should be investigated. With better care and management at least some of the ewes can be mated twice every year.

The number of lambs per birth increased at a decreasing rate from one lambing to the next until the maximum was reached at 5 to 7 years of age.

Tests have shown that no effective selection for high lambing percentages was practiced. In fact selection was slightly against it. The percentages of twin born ewes at 2, 3, 4, 5, 6 and 7 years of age was; 21.2, 17.9, 14.5, 15.1, 10.3 and 5.4, respectively. It seems that there was a slight tendency to select single born ewes and ewes lambing singles. This cannot be explained by conscious selection against the character. Most likely selection was based on appearance alone. The more prolific ewes usually look poorer than the less prolific ones, especially after being burdened with the gestation and suckling period. Consequently a higher proportion of them was discriminated against. Death and disease are also expected to be more frequent among ewes with high lambing percentages.

Future selection should be based on actual performance of the ewes and on the pedegree records, rather than the condition of the ewes at the time of selection. It should also be done within season and age groups or they should be properly corrected for. The regression of the second lambing on

the first was .073 and the regression of the average of the third and fourth lambings on the average of the first and second lambings was .371. When selection is based on the first lambing record ewes which gave twins will give .073 more lambs, in their second lambing, than ewes which gave singles. If selection is based on the average of the first and second lambings the average of the third and fourth lambings is expected to increase by .371 lambs.

The repeatability and heritability of the number of lambs per birth were low. The Rahmani sheep is similar to the foreign breeds of sheep in this respect. Still some progress could be achieved if ewes are selected on the basis of their first and second lambings. In selecting ewe and ram lambs weight should be given to their type of birth and also to that of their dams.

Summary

The lambing records of 279 ewes kept on the experimental farm of the College of Agriculture, University of Alexandria, were studied. The effect of year on lambing percentage was highly significant. Summer lambings, from March to August, had more lambs per birth than winter lambings, from September to February, but the difference was not statistically significant. The number of lambs per birth increased as the ewes increased in age. The maximum was reached at the age of 5 to 7 years. Twin born ewes had more lambs per birth than single born ewes, but the difference was not significant.

The repeatability of number of lambs per birth was .056 using the intra-ewe correlation for ewes with four lambings from 2 to 7 years of age. The heritability was .08 based on the regression of the type of birth of the offspring on that of the dam. Males were 48.2% of all lambs born.

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ECONOMIC IMPORTANCE OF TRAITS AND SELECTION INDEXES FOR BEEF CATTLE

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SINCE the introduction, by Hazel (1941, 1943), of new techniques for incorporating genetic and economic information in selection indexes for swine, much work has been done with various classes of livestock. When improvement for more than one trait is desired, Hazel (1941) has shown the selection index to be a more efficient means of utilizing the additive genetic variance than selection for one trait at a time or by selection on the basis of independent culling levels. His index was designed to permit the attainment of the maximum genetic progress by increasing economic usefulness with selection.

Hazel (1952) developed an index for the selection of beef cattle using assumed values for heritabilities, correlations and economic values. Insofar as is known, no application has been made of this method for selecting beef cattle using actual economic and genetic data. The purpose of this study was to determine the relative economic importance of traits affecting net income in beef cattle and to develop a selection index designed to attain the maximum genetic progress toward increasing net income per hundred weight of the finished product.

Materials and Methods

Any genetic improvement in traits of economic importance should result in a greater net income both to the feeder and breeder. Other things equal, calves with the ability to gain more rapidly on less feed or to finish in less time will produce a greater net return to the feeder. In order to obtain this type of calf, he will have to pay a premium to the breeder. Therefore, selection of livestock should be designed to increase the over-all net income per unit of the finished product. In this study, net income per hundredweight of the finished steer was the criterion used as the measure of economic worth.

The data consisted of observations made on 118 Hereford steers by 19 sires. These steers were bred, fed and slaughtered by the Colorado Agricultural Experiment Station in the six years, 1946–1951. They represented the unselected male calves of four years' production of cattle assigned to the project. These calves were born during March, April, and May and remained with their dams on range land typical of the San Juan

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Basin in Southwestern Colorado until weaning time in late November or early December. The steer calves were then moved to the station feedlots at Fort Collins where, following a short adjustment period, they were individually fed with the goal of a constant slaughter grade of low choice. This goal was not perfectly attained and some variation in slaughter grade was recorded. The initial weight was taken at the beginning of the feeding period or approximately one month after weaning. It was closely correlated with actual weaning weight and was used as the weaning weight in this study. Unadjusted weaning weights were used because it was felt that correlations between traits developed about the true weights might reveal biological relationships that adjusted weights might fail to reveal. The random distribution of ages of dams within the sire groups should have provided unbiased estimates of the paternal half-sib heritabilities and genetic correlations without adjustment of individual records.

To obtain the estimate of relative economic importance of traits, net income values were computed on the individual steers and the multiple correlations between various traits and this net income were studied. The standard partial regression coefficients served as the estimates of relative economic importance of the traits. Average slaughter steer prices by grades for the Denver livestock market for the twelve year period 1940–1951 were used to compute gross income per steer. Costs of production subtracted from this gross income to obtain net income per calf were: rancher costs of producing a calf, based upon replies to questionnaires sent to ranchers which were checked and evaluated by cattle specialists and economists at the Colorado Agricultural Experiment Station; feed costs, based upon Colorado grain and supplement prices for the same twelve year period; and other feedlot costs, based upon Burdick's (1954) studies which indicated that other feeding costs exclusive of interest and depreciation on corrals and equipment averaged about 20% as much as the feed costs or 16% of the total feedlot costs for the 1940–1951 period. Allowance of $4.08 per head was made for interest and depreciation. To remove year, type,[2] and sire effects, correlations between various phenotypic traits and between these traits and the net income per hundredweight were computed on a block within block type of analysis of variance and covariance. The use of standard partial regression coefficients to determine the relative importance of several independent variables in determining one dependent variable is well illustrated by Wallace and Snedecor (1931). These furnished the estimates of relative economic importance of the traits.

Heritabilities were estimated by the use of paternal half-sib intra-class correlations $\frac{V_S}{V_S+V_E}$, where V_S is the sire variance and V_E is the individual variance. This was divided by the relationship among steers, 0.25, within

[2] Comprest and conventional type steers were included in this study. Since the difference in type is due to a single gene with major effects and since this wide variation is not now generally found in herds, the computations were made on a within type basis.

sire groups to give heritability. Genetic variances and covariances were obtained by dividing sire variances and covariances by the same half-sib relationship. Genetic correlations were obtained by dividing genetic covariances by the square root of the product of genetic variances.

After computation of the covariances between the various traits and the aggregate genotype, Cov X_iH, the partial regression coefficients in the index were calculated from simultaneous equations using covariances, Hazel (1952), instead of the correlations used by Hazel (1941) in his original studies, thus:

$$\begin{aligned}
&b_1\,VX_1 + b_2\,\text{Cov.}\,X_1X_2 + \ldots + b_n\,\text{Cov.}\,X_1X_n = \text{Cov.}\,X_1H\\
&b_1\,\text{Cov.}\,X_1X_2 + b_2\,VX_2 + \ldots + b_n\,\text{Cov.}\,X_2X_n = \text{Cov.}\,X_2H\\
&\qquad\qquad\qquad

TABLE 1. PRICES PAID PER HUNDREDWEIGHT FOR 700–900 LB. SLAUGHTER STEERS FOR THE 12-YEAR PERIOD, 1940–1951, DENVER, COLORADO

Grade	Price	Price differential between grades
Choice	$21.66	
		$1.76
Good	19.90	
		2.29
Medium	17.61	

below average, .10% was added to or subtracted from the average variable feed costs for cows.

The average weaning weight was 397 with a standard deviation of 60 lb. and the average age 238 (standard deviation = 17 days). An intra class correlation of .38 indicated a difference in weaning age of calves in the different sire groups. This probably resulted in increasing the heritability estimate for weaning weight. Correlations indicated that increased weaning weight resulted in decreased feed efficiency, as measured by pounds of feed required per pound of gain, and in time required to finish.

TABLE 2. ESTIMATES OF COSTS OF PRODUCING A FEEDER CALF, FOR THE 12-YEAR PERIOD 1940–1951, IN THE INTERMOUNTAIN REGION OF COLORADO

Item of expense	Cost	
Fixed costs		
Interest on cow	$5.00	
Taxes	.50	
Replacements	2.00	
Death loss	1.50	
Bull costs per cow	6.20	
Overhead	5.00	
Transportation	4.80	
Labor	10.00	
Total fixed costs [a]		$35.00=41% of total costs
Variable costs		
Pasture	$16.00	
Hay and cottonseed meal	$35.00	
Total variable costs [b]		$51.00=59%
Total		$86.00
Calf crop 88%		
Cost per calf, $86.00÷88%=$97.73.		
Total fixed cost per calf		$39.78
Total variable cost per calf		$57.95

[a] Fixed costs are on a per head basis.

[b] Variable costs vary directly with feed intake and appear to be proportional to the weight of the dam.

Feed cost in the feedlot were based upon actual feed consumption of the individual steer charged at the rate of $2.00 per cwt. for the feed. Average feed consumption was 3053 lb. per steer for an average feed cost of $61.06. Other feedlot costs, including allowance for interest and depreciation on corrals and equipment, were $16.20, or an average cost of $0.077 per day in the feedlot.

Phenotypic correlations between the various items are indicated in table 3. Weaning weight was highly correlated with net income per hundred-

TABLE 3. PHENOTYPIC CORRELATIONS BETWEEN TRAITS AFFECTING NET INCOME

(Correlations were computed using block within block type of analysis of variance to remove year, type and sire effects)

	Feedlot gain		Days on feed	Grade at		Feed per lb. gain	Slaughter wt.	18 mo. wt. of dam	Net income per cwt.
	Total	Daily		Weaning	Slaughter				
Weaning weight	−.45	+.07	−.56	+.59	+.20	+.55	+.63	−.01	+.80
Total gain		+.54	+.74	−.49	+.13	nc	+.41	nc	−.15
Daily gain			−.16	−.35	+.23	+.51	+.53	+.18	+.37
Days to finish				−.52	−.03	−.10	+.07	−.04	−.46
Weaning grade					+.10	nc	+.17	nc	+.49
Slaughter grade						+.08	+.32	+.04	+.46
Feed per pound gain							nc	−.13	+.21
18-mo. Wt. of Dam									−.32
Slaughter wt.									+.68
Total feed consumed									−.02

Level of significant values for 89 degrees of freedom 5% r=.206
1% r=.269

nc=Correlations not computed.

weight, slaughter weight, feed per pound gain, and weaning grade. Heavier weaning calves required a shorter feedlot period to finish which resulted in a lower total gain in feedlot. The lighter steers at weaning made more efficient gains, although daily gains were slightly less. The correlation between weaning weight and 18-month weight of dam was −.01. The negative correlation between 18-month weight of dam and net income indicates that, weaning weight and other traits being equal, calves from lighter cows give a greater net return than calves from heavier cows. This is due to the lower cost of maintenance of the dam. Other traits highly correlated with net income were daily gain, days to finish, weaning grade, slaughter grade and slaughter weight.

Results of the multiple correlation studies are given in table 4. The standard partial regression coefficient give the optimum weighting of the various traits determining net income, on the basis of their importance and the interaction between these traits. The importance of weaning weight in determining net income per hundredweight was readily apparent from the high standard partial regression coefficient which it received in all multiple correlations. Other important traits were daily gain, slaughter

grade, feed per pound of gain and 18-month weight of dam. The multiple correlation of weaning weight and grade with net income was only slightly greater than the simple correlation between weaning weight and net income. Similar results were observed for days to finish which depended largely on weaning weight. The highest correlation of any two independent traits with net income per hundredweight was obtained with weaning weight and daily gain.

Heritability estimates obtained by the use of half-sib correlations in

TABLE 4. MULTIPLE CORRELATIONS WITH NET INCOME PER HUNDREDWEIGHT AND RELATIVE ECONOMIC VALUES

Multiple correlation with net income N		Standard partial regression coefficients: Weaning weight W	Weaning grade G	Daily gain R	Days to finish F	Slaughter grade S	Feed per lb. gain E	18-mo. wt. of dam D
r_{NW}	=+.80	+1.00						
$R_{N \cdot WG}$	=+.80	+ .78	+.03					
$R_{N \cdot WR}$	=+.86	+ .77		+.32				
$R_{N \cdot WF}$	=+.80	+ .78			−.03			
$R_{N \cdot WS}$	=+.85	+ .73				+.32		
$R_{N \cdot WE}$	=+.84	+ .98					−.33	
$R_{N \cdot WD}$	=+.85	+ .79						−.31
$R_{N \cdot WRF}$	=+.86	+ .79		+.32	+.03			
$R_{N \cdot WRS}$	=+.89	+ .73		+.26		+.26		
$R_{N \cdot WRE}$	=+.86	+ .86		+.24			−.14	
$R_{N \cdot WRD}$	=+.93	+ .76		+.38				−.38
$R_{N \cdot WFS}$	=+.86	+ .69			−.07	+.32		
$R_{N \cdot WFE}$	=+.85	+1.04			−.08		−.35	
$R_{N \cdot WFD}$	=+.85	+ .79			−.01			−.31
$R_{N \cdot WSE}$	=+.89	+ .91				+.30	−.31	
$R_{N \cdot WSD}$	=+.91	+ .73				+.33		−.32
$R_{N \cdot WED}$	=+.91	+1.01					−.40	−.36
$R_{N \cdot WRSD}$	=+.97	+ .72		+.33		+.26		−.38
$R_{N \cdot WRSED}$	=+.98	+ .85		+.20		+.28	−.23	−.39
$R_{N \cdot WRFSD}$	=+.97	+ .73		+.33	+.02	+.26		−.38
$R_{N \cdot WRFSED}$	=+.98	+ .90		+.20	+.07	+.27	−.25	−.39
$R_{N \cdot WRFE}$	=+.86	+ .91		+.23	+.07		−.17	

All correlations were highly significant.

this study were higher than reasonably could be expected. Heritability estimates of .81 for weaning weight and .92 for days on feed were near the maximum limit. Heritability estimates of 1.57 for daily gain and 1.46 for feed per pound gain were greater than the maximum limit of heritability. An estimate of −.13 for slaughter grade indicated that the objective of feeding to a constant slaughter grade had been fairly well attained in the different sire groups. Also the progeny of these Hereford sires had genetic constitutions equipping them to reach the desired grade, at least eventually. Because of the low heritability for slaughter grade it was not included in the index computations. Eighteen month weight of dam was not included since no data were available for computing heritability. If the relation between these estimates is proportional to the relation between the actual heritabilities then their use in an index would not bias it. Heritability

values of 1.0 were used for daily gain and feed per pound gain since this is the maximum limit of heritability. This may have biased the index if the causes for their being greater than unity also acted to give higher heritability estimates for the other traits.

The four traits, weaning weight (W); daily gain (R); days to finish (F); and feed efficiency (E) were used in the determination of the aggregate genotype in the index computations. The genetic correlations for the traits used in the index computations, were: $r_{GWGR}=+.25$; $r_{GWGF}=-.82$; $r_{GWGE}=+.31$; $r_{GRGF}=-.26$; $r_{GRGE}=+.05$ and $r_{GFGE}=-.36$. The covariances between these traits and the aggregate genotype were: Cov. $X_WH=+3{,}256.42$; Cov. $X_RH=+2.84$; Cov. $X_FH=-1{,}002.03$ and Cov. $X_EH=+11.13$.

Solution of the simultaneous equations gave the partial regression coefficients, betas, for the index values. These beta's for Index 1, I_1, were; $b_W=+.58\pm.04$, $b_R=+18.64\pm9.30$, $b_F=-.73\pm.10$ and $b_E=-5.85\pm3.37$. The index then becomes $I_1=+.58\,W+18.64\,R-.73\,F-5.87\,E$. A correlation of .95 was obtained between the index and the aggregate genotype. This high correlation was due primarily to the high heritabilities used in the computations. On the basis of the standard errors of the coefficients, weaning weight appears to be the most reliable of the traits, while feed efficiency appears to be the least reliable. Multiplication of these beta's, or coefficients, by the standard deviation of the phenotypes, σX_I, gives an indication of the traits relative importance in determining the index values. The products of the betas and standard deviations are: $b_W\sigma X_W=(.58)\ (67.40)=39.09$; $b_R\sigma X_R=(18.64)\ (.2159)=4.02$; $b_F\sigma X_F=(-.73)\ (24.1039)=-17.60$ and $b_E\sigma X_E=(-5.85)\ (.6755)=-3.95$. This indicates that weaning weight is over two times as important in determining the index value as days to finish and that daily gain and feed efficiency are the least important.

One might ask what the effect of deleting a variable would be upon the efficiency of the index. The Gauss multipliers used to obtain the original beta's were used to study the effect of the deletion of various traits from the index. The indexes obtained by this method were:

$$I_2=+.54\,W+24.87\,R-\ .75\,F;\quad RI_2H=.95$$
$$I_3=+.75\,W+24.75\,R-9.04\,E;\quad RI_3H=.91$$
$$I_4=+.59\,W-\ .75\,F-8.46\,E;\quad RI_4H=.95$$
$$I_5=+.70\,W+34.80\,R;\quad RI_5H=.91$$
$$I_6=+.54\,W-\ .80\,F;\quad RI_6H=.94$$
$$I_7=+.78\,W-12.64\,E;\quad RI_7H=.91$$

A correlation of .90 with the aggregate genotype was obtained using weaning weight alone.

This study indicated that weaning weight alone was an accurate basis for selection. The addition of daily gain or feed efficiency did little to increase the efficiency of selecting for the aggregate genotype. Heavy

weaning weight and rapid finishing ability appear to be the most important traits to select for in attempting to increase net income from combined calf raising and calf feeding enterprises.

Index 8 was constructed using the actual heritability estimates (1.57 for daily gain and 1.46 for feed per pound of gain). This gave 50% greater importance to daily gain than did Index 5 where heritability estimates were limited to 1.0. (I_8=W+72R; I_5=W+50R). The correlation between I_8 and the aggregate genotype was .92. On the basis of Index 8 weaning weight would be 4.3 times as important in determining the index value as daily gain.

Summary

A study was made to determine the relative economic importance of weaning weight and grade, daily gain, days to finish, slaughter grade, feed per pound of gain, and cow maintenance costs in determining net income in a calf raising and feeding operation. A selection index designed to attain the maximum genetic progress toward increasing net income per hundredweight of the finished product was developed. Price and cost data were applied to 118 Hereford steer calves, bred and fed by the Colorado Agricultural Experiment Station, to obtain individual net income estimates. The net income estimates were divided by each 100 lb. slaughter weight to place net income in dollars on the basis of one hundred pounds slaughter weight.

Multiple correlation studies, using net income per hundredweight as the dependent variable, indicated that weaning weight was the most important trait affecting net income. Weaning grade and days to finish did not add to the information provided by weaning weight alone. Weaning weight and daily gain gave the highest multiple correlation with net income per hundredweight of any combination of two independent variables. Other important traits, as indicated by the standard partial regression coefficients, were slaughter grade, feed per pound gain and 18-month weight of dam.

Heritability estimates were computed for weaning weight W; daily gain, R; days to finish, F; and feed per pound gain, E. The standard partial regression coefficients, obtained when these four traits were used as the independent variables, were used as the estimate of relative economic importance. The index containing the four variables was I=+.58 W+18.64 R—.73 F—5.87 E. Because of the greater standard deviation, weaning weight was over twice as important as days to finish in determining the index value of the individual and feed pound gain and daily gain were least important. This study indicated that weaning weight alone was an accurate basis for selecting for increased net income in these Hereford calves. Another simple index apparently of considerable accuracy would be I_8=W+72G.

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STUDIES ON BOVINE OCULAR SQUAMOUS CARCINOMA ("CANCER EYE") III. INHERITANCE OF EYELID PIGMENTATION [1, 2]

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THE absence of eyelid pigmentation is considered an important predisposing factor in the development of "cancer eye" in cattle. Lush (1925), Wernicke (1935), Guilbert *et al.* (1948) and Bonsma (1949) all observed a higher incidence of the disease among animals with little or no lid pigmentation than among those with more heavily pigmented lids. The number of cases of cancer eye observed in those studies (33 out of some 4500 animals) was too limited to establish with certainty the relationship between cancer and pigmentation. However, a more recent study by Anderson *et al.* (1957) included 842 animals over four years of age with a total of 338 lesions, each considered on gross inspection to be carcinoma or a benign precursor of carcinoma (Russell *et al.*, 1956). The lesions developing on the lids were definitely related to lid pigmentation, whereas those that developed on the eyeball showed little, if any, relation with lid pigmentation. The much rarer lesions on the nictitans and caruncle, showed no consistent trend with pigmentation.

Information on the inheritance of eyelid pigmentation would be of interest in view of these results, because selection for an increased amount of pigment could reduce the incidence of cancer eye lesions on the lids. This probably would not have much effect in reducing the incidence of lesions developing on the eyeball, nictitans and caruncle.

Materials and Methods

The animals were Herefords from the Turner Ranch [4] at Sulphus, Oklahoma, and two experimental herds belonging to the Oklahoma Agricultural Experiment Station [5] located at El Reno and Stillwater, Oklahoma, respectively. As a routine part of a project investigating the genetic aspects

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of cancer eye in these herds, records of eye health and eyelid pigmentation were obtained. The records consist in part of a stamped outline of two eyes onto which the location and kind of each lesion and pigmentation pattern around the eye was drawn, either from a visual inspection of the eye, or from colored photographs.

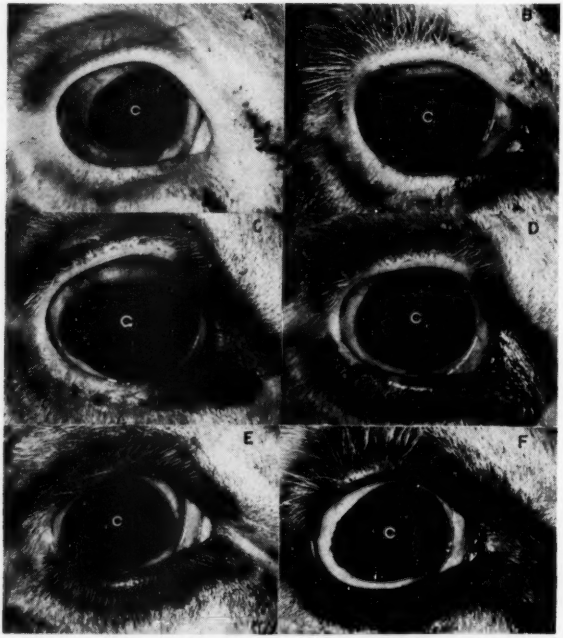

Figure 1. Examples of eyes with different amounts of pigmentation on the lids. A has zero pigmentation; B has 20% pigmentation; C has 40%; D has 50%; E has 90%; and F has 100%.

Present data refer to the amount of pigmentation on the skin of the eyelids. This was estimated from the stamped outlines as a percentage of the entire lid length covered by pigment, by counting the number of units covered by pigment on a scale which divided lid length into 100 equal units. Figure 1 shows examples [6] of eyes having different amounts of lid pigmentation.

Errors in measurement of pigmentation sometimes occur from inability to distinguish between an eye completely surrounded by very light pig-

[6] For the illustrations of pigmentation, the authors are indebted to Franklin R. Smith, medical photographer at The University of Texas M. D. Anderson Hospital and Tumor Institute.

ment and one with a total absence of pigment, or between dirt and/or a yellowish-waxy substance on a small area of the lids and the actual presence of pigment there. The effect of the first error is to score eyes as non-pigmented when actually they may be pigmented, and the effect of the second error is to score eyes as pigmented when they may be non-pigmented. These errors would tend to cancel in averages, but would tend to reduce a correlation or regression involving pigmentation towards zero. It seems unlikely that these errors are important because the repeatability of amount of pigmentation on the same animal at different ages was high. A repeatability estimate of .99 was obtained for 43 animals, indicating that errors in measurement are negligible for the most part and that little gain in accuracy would be had by considering an average value of pigmentation from two or more observations.

Since the pigmentation values for either eye ranged from zero to 100% with relatively few values of 100, a transformation converting percentages to angles was used, as recommended by Snedecor (1946). The effect of the transformation was to spread the scale in the regions near zero and 100%. The transformed values for each eye were used in the analyses which follow but, for the purposes of discussion, they were converted back to percentage units. All observations and scoring of eyelid pigmentation were made by the senior author.

Effect of Sex and Age Differences on Pigmentation

Sex. The average amount of lid pigmentation was 29% in males and 35% in females in the Stillwater herd. This difference was ascribed to chance. There was no indication of differences between males, females, or steers (of which there were only 23) in the El Reno herd. Data from the Turner Ranch pertained to one sex because only females retained for the breeding herd were observed.

When the herds were combined, females tended to have more lid pigmentation than males (31 vs. 26%), but had a smaller amount than steers (31 vs. 35%); however, none of these differences were significant. The observed differences between sexes in amount of lid pigmentation were considered too small to warrant correction. Small sex differences in body pigmentation of cattle have been reported by Dunn *et al.* (1923), Briquet and Lush (1947) and Koger and Mankin (1952).

Age. Briquet and Lush (1947) observed that the amount of white body area declined slightly from youth to maturity in Holsteins. They ascribed this to the fact that legs, which are largely white, were a larger fraction of the body area, as seen from the side, in young animals than in older ones. Present observations showed that dams in the El Reno and Stillwater herds had more lid pigmentation than did their young offspring (30 vs. 23%), while the opposite was observed in the Turner herd (13 vs. 16%). Combining the herds, older animals had an average amount of 23% and

the younger ones had an average of 20%. The difference was less than twice its standard error and could easily have occurred by chance. Part of the difference in favor of the older animals, particularly in the El Reno and Stillwater herds, was probably due to a tendency to score young animals as having less lid pigmentation than cows because of their smaller eye size, even though both large and small eyes may have had the same relative amounts of pigmentation on the lids. Such an error would occur when pigmentation was recorded onto the stamped outline of eyes, either from visual observation of the live animals, or from inspection of colored photographs.

Guilbert *et al.* (1948) noted the development of new spots of pigment on the lids as well as an increase in the relative size and intensity of these spots as the animal matured. For hair color, Koger and Mankin (1952) found that calves tended to be darker than cows and that mature animals tended to be darker in good years than during droughty years.

No corrections were made in the present data for the effect of age on lid pigmentation. This effect was negligible in the Turner herd because the majority of animals (over 99%) were at least two years of age and the remainder were over one year of age. Any changes in pigment distribution which might occur shortly after birth had probably occurred by the time these observations were made. The calves belonging to the Oklahoma Station were seen from one to seven months of age, so conceivably some of them could have been seen before pigmentation was fully expressed.

Age of dam seemed to have no effect on amount of lid pigmentation, either when comparing the average amount in the progeny of 3, 4 . . . 14 year old dams, or in the progeny of dams having 1, 2 . . . 5 calves. Wright and Chase (1936) reported that age of dam and environmental accidents during embryological development were important factors in determining pie-bald spotting in guinea pigs.

Results

Regression of offspring on parent and the intra-class correlation between paternal half-sibs were the methods used for estimating heritability of amount of pigmentation on the skin of the lids. The procedures and contributions to the estimates from the additive and non-additive genetic variance have been presented by Lush (1940, 1948) and Lerner (1950) and need not be considered here. Table 1 shows the number of animals involved with each method of estimation. The estimates of heritability and their confidence intervals are shown in table 2.

The estimates of heritability ranged from .41 to .50. They are surprisingly consistent in magnitude, considering the range of some of the confidence intervals. There are no important differences among the various estimates for the different herds or by the different methods of estimation.

TABLE 1. NUMBER OF ANIMALS INVOLVED IN THE VARIANCE AND REGRESSION ANALYSES

Source of data	Variance analysis		Regression analysis	
	Total number of animals	Number of sires	Intra-sire offspring-dam comparisons [b]	Number of sires
Turner ranch	601	94	195	22
El Reno	352	22	330	22
Stillwater [a]	164	—	164	—

[a] Sires were not individually identified in this herd, so regression is not intra-sire.
[b] Dams with more than one offspring had their record repeated for a paired comparison with each of the offspring. A total of 513 different dams were observed for pigmentation, of which 158, 191, and 164 were in each of the herds, respectively.

Data from all the herds were pooled to yield an estimate of .44, based on a regression of offspring on parent utilizing 733 parent-offspring comparisons. The 95% interval was .31 to .57. A pooled paternal half-sib estimate for 953 offspring by 116 sires was .46 with an interval of about .32 to .60.

Another estimate, though a maximal one, was obtained by correlating the pigmentation in the right and left eyes of the same animal. This approach takes into account all the additive and non-additive genetic variance besides environmental effects common to both eyes. The correlation for all herds, including 1630 pairs of eyes, was $.54 \pm .02$. That this is only a little larger than those obtained by methods which include little except the additively genetic variance indicates that dominance, epistasis, and environmental differences common to both eyes have only small effects on amount of lid pigmentation.

A slight maternal effect was found in the data. This was evidenced from reciprocal matings, involving sires with small amounts of lid pigmentation and dams with highly pigmented lids, or sires with highly pigmented lids and dams with small amounts of lid pigmentation. The offspring

TABLE 2. ESTIMATES OF HERITABILITY OF AMOUNT OF PIGMENTATION ON THE SKIN OF THE LIDS

Source of data	Method of estimation [a]	Heritability estimate	95% confidence interval
Turner ranch	R	.50	.24 to .76
Turner ranch	P	.46	.26 to .68
El Reno	R′	.41	.24 to .59
El Reno	P	.50	.35 to .65
Stillwater	R″	.48	.20 to .75
Pooled data	R″	.44	.31 to .57
	P	.46	.32 to .60

[a] R refers to intra-sire regression of daughter on dam.
R′ refers to intra-sire regression of offspring on dam.
R″ refers to regression of offspring on dam.
P refers to paternal half-sib intra-class correlation.

had a higher average amount of lid pigmentation when the dam was the highly pigmented parent.

Further evidence of a maternal effect is apparent from table 3. In each instance the percentage of animals with pigmented lids was higher when the dam was the highly pigmented parent. Actually no sires showed a complete lack of pigment, although one did have zero pigmentation of the lids and a spot of pigment adjacent to the lid area. This sire was included in the matings as non-pigmented, which could have affected the percentage of progeny showing pigment for the matings in which he was involved, but not in the ones in which both parents were pigmented.

TABLE 3. INCIDENCE OF PIGMENTED LIDS IN PROGENY FROM PARENTS HAVING PIGMENTED AND NON-PIGMENTED LIDS

Mating type [a]		Number of matings	Percentage incidence of pigmented lids in the progeny
Sire	Dam		
Pigmented (1)	Non-pigmented	24	71
Non-pigmented	Pigmented (1)	11	81
Pigmented (2)	Non-pigmented	60	65
Non-pigmented	Pigmented (2)	20	75
Pigmented (2)	Pigmented (1)	23	70
Pigmented (1)	Pigmented (2)	66	90
		204	

[a] Pigmented (1) means pigment present on lids of one eye only.
Pigmented (2) means pigment present on lids of both eyes.
Non-pigmented means no pigment on lids of either.

The El Reno herd was divided into four separate lines rather unrelated to each other. Sires within each were mated only to mates of the same line. Thus, an intra-sire regression of offspring on dam was unaffected by differences between line means. The variance concerned in such a regression was only that between cows of the same line. A higher than average relationship among cows of a given line reduced this variability so that among them the genetic variability was less than would be expected in a random sample of the whole breed. However, the paternal half-sib estimate of .50 for the same herd (uncorrected for the average relationship within lines being higher than that between lines) would be larger than would apply to a random sample because differences between lines contributed to it.

The Turner herd was not divided into lines, but dams were related to one another, which reduced the genetic variability. The estimate of .50 from an intra-sire regression of daughter on dam was a bit smaller than would be found in a random sample of the breed. Since the sires were somewhat homogeneous because of some linebreeding, the paternal half-sib estimate of .46 was also a little too small to apply to a random sample of the breed.

Non-linearity between the present scale of measurement of pigmentation and primary gene effects could have made the estimates too small. Its presence in the data may be indicated by the skewness of the frequency distribution of amount of pigmentation shown in figure 2. This could mean

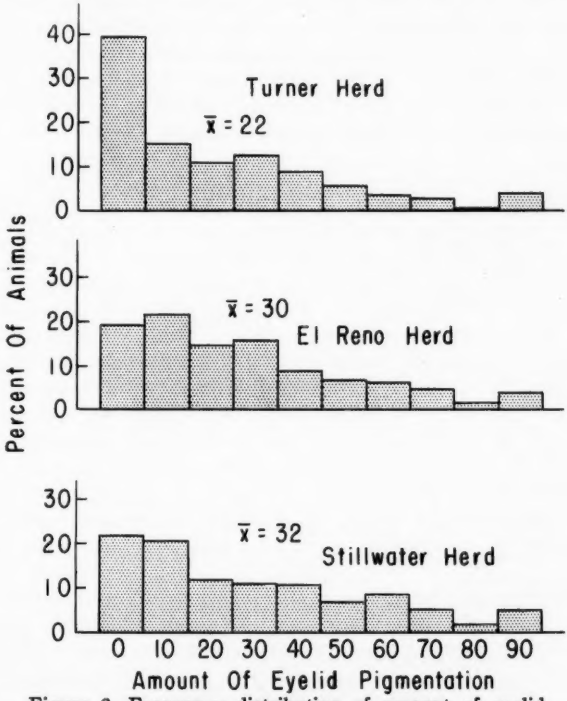

Figure 2. Frequency distribution of amount of eyelid pigmentation.

that a given gene substitution near the extremes of the scale (especially near the zero end) produces a smaller visual effect than one near the middle. Hetzer (1954) reported the possibility of such an effect for pigmentation in swine, as did Wright and Chase (1936) in guinea pigs, and Briquet and Lush (1947) in their study of body pigmentation in Holstein cattle.

Differences in sex and age, if they were at all important, would have tended to reduce the size of the present estimates for the El Reno and Stillwater herds, but not those for the Turner heard, where age and sex seemed not to cause any differences in the mean pigmentation. Errors in measuring the amount of pigmentation would have tended to reduce the

estimates for all three herds, but particularly for the El Reno and Stillwater herds where pigmentation was generally estimated from observations on live animals, while in the Turner herd it was estimated by a more accurate method of inspection of colored photographs of eyes.

In the light of factors affecting the individual estimates of heritability, the pooled estimates in table 2 are considered the most reliable for present purposes because of the large number of animals involved in each and the possibility that some of the factors influencing them were cancelled in the pooling process. The values of .44 and .46 are probably slight underestimates of heritability of amount of pigmentation.

Discussion

The estimates of .44 and .46 indicate that about 45% of the individual differences in the amount of pigmentation on the skin of the lids are conditioned by additive effects of genes. The remaining 55% could be due to (1) dominance or epistasis; (2) environmental effects or accidents, perhaps early in embryology; (3) errors in measurement of pigmentation, and (4) any discrepancies caused by non-linearity between the present scale of measurement and primary gene effects. That dominance or epistasis causes little of this .55 is indicated by the concordance between right and left eyes on the same animal being only a little larger than the .45 estimated for heritability. That errors in measurement cause little of this is indicated by the high repeatability of the measurement of the amount of lid pigmentation. Most of the remainder is probably the result of environmental accidents during embryological development, and discrepancies caused by non-linearity between the scale of measurement and gene effects.

No estimates of heritability of lid pigmentation were found in the literature. Indirect evidence of one is available from the distribution patterns of red pigmentation about the eyes of 591 animals observed by Guilbert *et al.* (1948). Their animals were tentatively classified as belonging to one of 6 pigment pattern classes.[7] These classes can be combined to include 1, 2 and 3 as one cell of a 2 x 2 table and class 6 as the cell diagonal to the first; 4 and 5 can be divided equally into the two remaining cells of the table. A correlation between the presence or absence of pigmentation in one eye and in the other eye can then be computed from the table. The correlation is .6 and compares favorably to the present one of .54, both of which are maximal estimates of heritability of lid pigmentation.

Other estimates were found that pertained to hair color in Herefords. Pound (1928) recorded the results of six possible coat color combinations among the parents. From 406 matings, a regression of the offspring's color score on mid-parent score was 44%. Hellstrom (1951) studied five shades

[7] The six classes and the number in each were as follows: 1, both eyes completely encircled with red (110); 2, one eye red, one eye broken red (60); 3, both eyes broken red (237); 4, one eye red, one clear (13); 5, one eye broken red, one clear (73); and 6, both eyes clear (98).

of hair color and found heritability to be 63% from 369 dam-offspring comparisons, and 49% from paternal half-sibs. Koger and Mankin (1952) devised a score for eight color shades for 437 weanling calves and their parents and obtained heritability estimates of 73 and 75% from regressions of offspring on dam and on mid-parent, respectively. Dunn *et al.* (1923) reported means of offspring from light and dark bulls which yield heritabilities of white spotting in Holstein cattle of 108 and 52%. From 343 rated offspring and their dams, Briquet and Lush (1947) concluded that the heritability of individual differences in the percentage of white spotting in Holsteins was more than 90%. The evidence is convincing that differences in pigmentation of hair are highly heritable.

The consistency and magnitude of the present estimates of heritability indicate that the animal's own phenotype should be the most important criterion in selecting for an increased amount of pigmentation on the skin of the eyelids. Attention to collateral relatives or progeny would help only a little except in deciding between phenotypically similar animals.

Selection for more pigmentation on the lids should be effective. Such selection would be expected to reduce the incidence of lesions that develop on the lids. It is unlikely that this would have much effect on the incidence of lesions on the eyeball, nictitans and caruncle because the association between these and pigmentation is small. It is also unlikely that such selection would result in more than a slight reduction in the general incidence of lesions because lesions on the lids are a small proportion of the total lesions. Anderson *et al.* (1957) noted that lesions on the eyeball, nictitans and caruncle were about three times as frequent as those on the lids. The heritability of .29 for cancer eye susceptibility found by Blackwell *et al.* (1956), points to direct selection for increased resistance to cancer eye as a more effective means of reducing the general incidence of the disease. Selection criteria would be the animal's own phenotype and information on the resistance of the parents, sibs, or off-spring. Considerable selection on own phenotype is automatic, so far as animals are culled when they develop serious lesions. However, this does not of itself lead to discarding any sons and daughters such animals had produced earlier. For herds or regions where lid lesions are a serious problem, or for herds shipping animals to such regions, an increased amount of pigmentation on the skin of the lids could also serve as a criterion for some mild early selection. More intense direct selection for increased resistance would occur later.

General observations indicate that lid pigmentation is not associated with "red neck", or with extension of hair pigment on the lateral aspects of the neck and head and below the ear. These are only general impressions and need further study. The relation between shade of coat color and amount of pigmentation on the eyelids was not studied. Pitt (1920) reported that animals with the darkest shade of hair color had pigment around the eyes and nose more often than pale brown animals.

Summary

The present study was undertaken to obtain estimates of heritability of the amount of pigmentation on the skin of the eyelids in Hereford cattle. The data were the pigmentation of 1117 offspring and 513 of their dams. The offspring were sired by 116 sires in three Oklahoma herds.

Heritability estimated from the regression of 733 offspring on dam was .44. The paternal half-sib intra-class correlation for 953 offspring by 116 sires yielded an estimate of .46. Possible biases in these and other estimates are considered. Means of reducing the incidence of cancer eye are also presented.

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ABSTRACTS OF PAPERS TO BE PRESENTED AT THE FORTY NINTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF ANIMAL PRODUCTION

The meetings are scheduled to be held at the Hotel Sherman in Chicago, Illinois, on November 29 and 30, 1957. Abstracts have been submitted for the following papers.

1. GENETIC AND PHENOTYPIC CORRELATIONS AMONG TRAITS IN BEEF CATTLE. R. C. Carter and C. M. Kincaid, *Virginia Polytechnic Institute.*

Genetic and phenotypic correlations among several traits were estimated using data from 195 steers and 190 heifers calved over a five year period, 1949–53, the progeny of 36 bulls. Genetic correlations were estimated from paternal half-sib analysis. Phenotypic relationships were obtained from product moment correlations using pooled intra year and station variances and covariances. The characters studied were, in the steers, weight at 6 months, feeder grade at weaning, daily gain in feedlot, TDN per cwt. gain, slaughter and carcass grades; in the heifers, weight at 6 months, feeder grade at weaning, yearling summer pasture gains and yearling feeder grade. No negative genetic correlations that would handicap selection are evident among the traits studied. Initial grade seems to be independent of subsequent gains, but gain in a particular period is highly correlated with grade at the end of the period. Initial grade is highly correlated with subsequent grades. Perhaps the most important relationships indicated were high positive genetic correlations between pre-weaning growth as indicated by weight at 6 months and subsequent gains in the feedlot (.66) in the steers or yearling pasture gains (.51) for the heifers. Selection for heavy weaning weights on a progeny basis should be effective in improving post weaning rate of gain. Genetic and phenotypic correlations among all traits will be presented.

2. RELATIONS BETWEEN CONFORMATION SCORES AND PRODUCTION FACTORS IN YEARLING STEERS. J. F. Kidwell, J. E. Hunter, P. R. Ternan, C. E. Shelby and R. T. Clark, *University of Nevada and U.S.D.A.*

Relations between conformation scores and several production factors were studied in a group of 98 yearling steers. The data were amenable to correlation and analysis of variance techniques. Under the conditions of this experiment, the data appear to support the following conclusions: There is no relation between feeder grade and subsequent rate or economy of gain. There is a positive relation of both feeder and slaughter grade with dressing percent and percent fat in the 9-10-11 rib. There is a negative relation between these two grades and percent bone and muscle in the 9-10-11 rib. Feeder grade is only slightly related to the percent of the various wholesale cuts. There is a high relation between feeder score and feeder price, a lesser association between feeder grade and slaughter price and a small relation between feeder grade and carcass price. There is no relation between slaughter score and rate or economy of gain. Slaughter score is related to carcass score, dressing percent and

percent bone, muscle and fat in the 9-10-11 rib. There is a low but real relation between slaughter score and percent of the wholesale cuts. Higher grading steers yield a lower proportion of round and a higher proportion of plate. There is a high relation between slaughter grade and slaughter price and a lesser relation between slaughter score and carcass price. These results tend to support and extend those of previous investigators.

3. THE INFLUENCE OF AGE, SEX, AND SEASON OF BIRTH OF CALF AND AGE OF DAM ON PREWEANING GROWTH RATE AND TYPE SCORE OF BEEF CALVES. Thomas J. Marlowe and James A. Gaines, *Virginia Agricultural Experiment Station.*

Least squares estimates of influences enumerated in the title were computed using data on 4,166 calves born on breeders' farms over four seasons, 1953–56, and receiving no supplemental feed. These estimates will be used in the Virginia program. All calves were weighed and scored for type between 90 and 300 days of age. Sex of calf had marked effects on growth rate but little effect on type. Estimated group means for average daily gain were 1.77, 1.70, and 1.58 for 511 bulls, 1,540 steers and 2,115 heifers, respectively. Type scores averaged 11.8, 11.2 and 11.7 for these groups. Age of calf had little influence on daily gain up to 240 days of age but a greater influence on type score. Estimated means of 30 day intervals from 90 to 300 days were 1.69, 1.68, 1.67, 1.66, 1.64, 1.60 and 1.49 for daily gain and 10.9, 11.2, 11.4, 11.6, 11.8, 11.6, and 11.5 for type score. Season of birth was an important source of variation in both traits measured. Seasons were divided as follows: Dec. 16–Mar. 15, Mar. 16–May 31, June 1–Aug. 31, and Sept. 1–Dec. 15. Estimated season means were 1.65, 1.69, 1.56 and 1.53 for growth rate and 11.7, 11.6, 10.7 and 11.6 for type score. Age of cow was the most important source of variation studied. Cows were grouped as 2, 3, 4, 5, 6, 7, 8, 9, and 10 or over. Estimated means of their calves were 1.44, 1.57, 1.63, 1.66, 1.70, 1.74, 1.68, 1.73 and 1.67 for daily gain and 10.9, 11.4, 11.4, 11.7, 11.7, 11.8, 11.7, 11.5 and 11.5 for type score.

4. THE RELATIONSHIP OF BIRTH WEIGHTS TO GROWTH AT VARIOUS STAGES OF DEVELOPMENT IN CATTLE OF VARIOUS BREEDING AT THE FLORIDA EVERGLADES EXPERIMENT STATION. M. Koger, R. W. Kidder, H. V. Clum and J. M. Liddon, *University of Florida*

Birth and weaning data were available from 875 calves born from 1932–55. Growth data to 24 months of age were available for 287 replacement heifers. Angus, Brahman, Devon, Angus x Brahman crossbreds, and two groups of Devon x Brahman crossbreds were the breed groups represented. On a within breed and year basis, the correlation between birth and weaning weight was .47 and for birth weight and gain from birth to weaning .31. Birth weight showed a nonsignificant negative correlation with gain from 6 to 12 months of age, but showed a significant positive relationship to gains made at other periods of growth with the coefficients ranging from .18 to .25. The correlation between birth weight and 24-month weight was .43. Correlations between gains made at various periods of post weaning development were generally low or negative with the next period but positive for further subsequent gains. This suggests a negative phenotype relationship between growth made during adjoining periods but that in general, growth during one period is basically positively related to growth at other periods.

5. GENETIC COMPONENTS OF VARIANCE AND COVARIANCE IN WEANING, YEARLING AND FEEDLOT PERFORMANCE OF HEREFORD STEERS. R. L. Blackwell, J. H. Knox and C. E. Shelby, *New Mexico Agricultural Experiment Station and U.S.D.A.*

The data for this study were obtained from 499 Hereford steers from 36 sires. Estimates of heritabilities and genetic correlations were obtained from paternal half-sib

variance and covariance components analyses. The traits studied were weaning weight (Y_1), weaning grade (Y_2), yearling weight (Y_3), yearling gain (Y_4), yearling grade (Y_5), weight per day of age as long yearlings (Y_6), final feedlot weight (Y_7), average daily gain in the feedlot (Y_8), slaughter grade (Y_9), and weight per day of age at the end of the feeding period (Y_{10}). Heritability estimates obtained for these traits were 0.08, 0.38, 0.10, 0.32, 0.40, 0.08, 0.70, 0.76, 0.88 and 0.77, respectively. Positive genetic correlations less than 0.3 were obtained between Y_1Y_3, Y_1Y_6, Y_1Y_8, Y_3Y_7, Y_3Y_8, Y_3Y_9, Y_3Y_{10}, Y_5Y_8, Y_6Y_7, Y_6Y_8 and Y_6Y_9. Negative genetic correlations from zero to —0.3 were obtained between Y_2Y_4, Y_4Y_5, Y_4Y_7, Y_4Y_8, Y_4Y_9, Y_4Y_{10}, Y_5Y_7, and Y_5Y_{10}. Positive genetic correlations from 0.3 to 0.6 were obtained for Y_1Y_7, Y_1Y_9, Y_1Y_{10}, Y_2Y_7, Y_2Y_{10}, Y_5Y_9, and Y_6Y_{10}. Negative genetic correlations from —0.3 to —0.6 were obtained between Y_1Y_2, Y_1Y_5, Y_2Y_3 and Y_2Y_6. Negative genetic correlations larger than —0.6 but less than —1.0 were obtained between Y_3Y_4 and Y_5Y_6. Genetic correlations between all other traits were positive and greater than 0.6.

6. HERITABILITY OF SOME ECONOMIC TRAITS IN RECORD OF PERFORMANCE BULLS. C. E. Shelby, R. T. Clark, J. R. Quesenberry and R. R. Woodward, *Agricultural Research Service, U.S.D.A.*

Data from 542 bull calves by 116 sires from 11 inbred lines tested in Record of Performance tests at the U. S. Range Livestock Experiment Station, Miles City, Montana, from 1940 to 1954, were analyzed. Estimates of heritability obtained by paternal half sib correlation were: birth weight 59, gain from birth to weaning (180 days) 40, weaning weight (180 days) 43, weaning score 60, gain in the feed lot 46, final weight (13 months) 77, and efficiency of feed utilization 32.

7. HERITABILITY OF GROWTH RATE IN BEEF CATTLE ESTIMATED FROM RESPONSE TO SIRE SELECTION. C. M. Kincaid and R. C. Carter, *Virginia Polytechnic Institute.*

The objectives of this experiment, carried out from 1947 to 1954, were to estimate, directly, heritability of post-weaning gains and progress to be made from selection, by progeny testing young bulls selected for high and low gains on a 168 day feeding test following weaning. Nineteen high gaining bulls averaged 2.24 lb. per day, 19 low gaining 1.65 lb. The difference (0.59 lb.) was slightly more than twice the within group standard deviation of gains on test. The 22 Hereford, 12 Angus, and 4 Shorthorn bulls were paired within breed (one high, one low gaining) and mated at random to grade Hereford cows. The steer progeny (total 177 head) were full fed 200 days following weaning. The heifers (192) were wintered largely on roughage and tested by gains on pasture their yearling summer. Differences between the progenies of the high and low gaining bulls averaged .10 lb. per day for the steers and .06 lb. for the heifers. Heritability estimates based on regression of progeny differences on sire differences ranged from .26 to .31 for the steers and from .21 to .26 for the heifers depending on weights used to adjust for differences in progeny numbers. When adjusted for difference in variance among sires and within the progenies, i.e. converted to standard measure, these estimates became .38 to .49 and .31 to .35 for the steers and heifers respectively.

8. EFFECTS OF NUTRITIONAL STRESSES ON SHEEP PRODUCTION. C. P. Stroble and J. W. Oxley, *University of Wyoming.*

Twenty-seven bred ewes were placed on three levels of feed and three levels of water in a factorially designed experiment for a duration of approximately four months, the exact time of which varied according to date of parturition. The levels of feed were 33⅓%, 66⅔%, and 100% of N.R.C. recommendations, and water was provided in

amounts of 33⅓%, 66⅔% and 100% of Morrison's estimate of one gallon per head per day. Data will be presented regarding production as measured by combined body weight, fleece weight, and lamb weight and expressed in terms of production per day. At 55 and 125 day intervals, wool samples were collected from the shoulder area, appropriately identified by skin tattoos, for fiber-diameter and length determinations. Data will be presented relative to nutritional effects of fiber diameter and length.

9. CREATININE AS AN INDEX MATERIAL FOR EVALUATING RUMINANT NUTRITION. John E. Butcher and Lorin E. Harris, *Utah State University.*

Index or indicator materials have been increasingly popular in determining digestibility of feeds. For balance trials it is necessary to have a measure of urinary as well as fecal output. Little has been reported on the use of index materials for urine. This field was investigated in a series of sheep and cattle trials with particular emphasis on the use of creatinine. Estimation of urinary nitrogen was used as a measure of the effectiveness of the index material. The independence of creatinine excretion and level of protein intake was verified. The diurnal variation in the excretion of urinary nitrogen and creatinine, and the creatinine-urinary nitrogen ratio was found to be significantly different for different times of day. Small samples of sheep urine collected morning and evening and composited were found to have essentially the same creatinine-urinary nitrogen ratios as samples from total collections. Therefore, creatinine may have merit as an index material for urine, with the limitation that average creatinine excretion must be determined for experimental animals prior to balance trials by index materials. Total daily excretion of urinary nitrogen and creatinine-urinary nitrogen ratio were found to be closely associated with level of protein intake when energy intake was relatively constant.

10. NUTRITIONAL USE OF TRANQUILIZERS IN CATTLE AND LAMB RATIONS. W. C. Sherman, W. H. Hale, W. M. Reynolds and H. G. Luther, *Chas. Pfizer & Co., Inc., Terre Haute, Ind.*

Tranquilizers tested included hydroxyzine, crude Rauwolfia vomitoria root and reserpine, an active principle of rauwolfia. In the first trial (110 days) all groups received Terramycin and oral stilbestrol. Controls and groups fed 2.4 mg. hydroxyzine per head daily and 25 mg. Rauwolfia had respective average daily gains (lb.) and feed efficiencies (lb. feed per lb. gain) of 2.88, 8.57; 3.13, 8.16; 3.25, 8.24. In a 168-day trial without other supplements gains and feed efficiencies were: control, 2.13, 10.96; hydroxyzine, 2.4 mg., 2.24, 10.51; Rauwolfia, 25 mg., 2.13, 11.13; reserpine, 60 mcg., 2.28, 10.21. In a parallel trial, all groups fed oxytetracycline, results were: control, 2.02, 11.36; hydroxyzine 2.33, 9.86; Rauwolfia 2.24, 10.63; reserpine 2.47, 9.70. With stilbestrol-implanted cattle, controls and hydroxyzine (1.25, 2.5, 10, 50 and 500 mg.) gave results of 2.25, 10.41; 2.83, 9.12; 2.68, 9.16; 2.82, 9.16; 2.74, 8.68 and 2.61, 9.16. Thus, growth was enhanced by hydroxyzine in all trials and by Rauwolfia or reserpine in 4 of 5. For lambs implanted with 3 mg. stilbestrol and 50 mg. oxytetracycline and fed hydroxyzine, 0, 0.24, 1.2, 6 and 30 gm. per ton of feed or Rauwolfia, 3 gm. per ton, gains and feed efficiencies were respectively: 0.477, 7.35; 0.473, 7.54; 0.547, 6.98; 0.498, 7.19; 0.485, 7.31; 0.551, 7.16. In a second trial, gains and feed efficiencies on 0 and 2 gm. hydroxyzine and 3 gm. Rauwolfia were, respectively, 0.415, 9.38; 0.531, 7.35 and 0.436, 8.70. Levels of tranquilizers fed did not visibly sedate the animals.

11. INTERACTIONS AMONG PROTEIN CONSUMPTION CALORIC INTAKE AND WEIGHT GAIN IN CALVES. C. F. Winchester, R. E. Davis and Meredith Morris, *U.S.D.A., Beltsville, Maryland.*

Metabolism data on 12 pairs of identical twin calves were recorded during a period of feed restriction lasting 6 months. Rates of gain and nitrogen retention were

closely related, the correlation coefficient (r) between gain and nitrogen retention on a within twin basis being 0.883. The r is significant at less than the 0.01 probability level. Calves fed at caloric maintenance were in negative nitrogen balance while losing weight, in positive balance while gaining and were calculated to have retained about a gram of nitrogen daily per 400-lb. animal when neither losing nor gaining weight. The calculated daily nitrogen intake level at which calves neither gained nor lost weight was 18 gm. for a 400-lb. animal; at this intake level each increase of one therm in energy intake resulted in an increase in nitrogen retention of approximately half a gram daily. Fecal nitrogen a function both of dry matter and nitrogen intake, was more closely related to the former than to the latter. On a within twin basis, the correlation between fecal nitrogen and dry matter was 0.721 (significant at the 0.01 probability level), between fecal nitrogen and nitrogen intake 0.592 (significant at the 0.05 probability level). Nitrogen intake was not significantly related to dry matter intake.

12. THE INFLUENCE OF PURIFIED MATERIALS ON THE DEVELOPMENT OF THE RUMINANT STOMACH. W. P. Flatt, R. G. Warner and J. K. Loosli, *Cornell University.*

Six calves were fitted with cannula type rumen fistulas at three weeks of age and housed on wooden platforms. Besides a daily feeding of milk they received one of the following "diets" through the fistula at regular intervals for 8–12 weeks; (1) Synthetic fiber-free diet; (2) Synthetic fiber-free diet + plastic sponges, (3) Synthetic fiber-free diet + cellulose sponges, (4) Solution of the sodium salts of acetic, propionic, butyric and lactic acids, (5) rumen juice and (6) plastic sponges. Treatments 1–4 resulted in marked development of rumen papillae while 5 and 6 did not. A section of rumen wall just caudal to the rumino-reticular fold was taken and the air dry weight of the mucosa and muscle layers determined. The percent of mucosal tissue was respectively for each treatment: 66.8, 81.2, 79.9, 65.2, 35.7 and 35.6. Six additional calves were managed as above and two received one of the following "diets" through the fistula; (7) Same as (4) above, (8) Ground plastic sponges, (9) Treatment (7 + 8). Papillary development was marked on treatments 5 and 7 and absent on 6. Percent of rumen mucosa was respectively for the three latter treatments: 52.1, 40.7 and 62.0. These data support the view that chemical rather than physical factors are responsible for the development of rumen papillae.

13. INTERRELATION OF MOLYBDENUM, COPPER AND COBALT ADMINISTERED ORALLY TO HEIFERS ON PASTURE. H. L. Chapman, Jr., *Everglades Experiment Station, University of Florida.*

Thirty-two yearling Brahman x Angus heifers were randomly divided into four lots of eight animals each and placed on a copper depletion-repletion type experiment to study copper-cobalt-molybdenum interrelationships. The heifers were grazed on pasture with common salt and steamed bonemeal available at all times. During the depletion period the following experimental treatments were employed: Lot 1. no treatment; Lot 2. 2.25 mg. of molybdenum per animal daily; Lot 3. 8 mg. of cobalt per animal daily; and Lot 4. a combination of groups 2 and 3. The experimental treatments were orally administered twice weekly. The animals which became depleted in copper, as indicated by blood and liver analyses, were given 0.5 gm. of elemental copper per week, in addition to the above treatments. Blood samples were taken every 28 days and analyzed for hemoglobin, packed cell volume, inorganic serum phosphorus and total copper content. Liver tissue samples were taken, by biopsy technic, every six weeks and analyzed for copper and iron content. Cobalt apparently facilitated the utilization of copper and iron by the animals receiving no molybdenum. Similarly cobalt apparently facilitated the utilization of liver iron for blood hemoglobin formation for the heifers receiving molydenum. However the criteria used did not indicate that cobalt alleviated the drop in liver copper stores which commonly occurs in conjunction with cattle receiving a high molybdenum intake.

14. THE INFLUENCE OF PREVIOUS CAROTENE INTAKES ON THE BIOLOGICAL VALUE OF CAROTENE IN THE BOVINE. E. S. Erwin, T. R. Varnell and C. B. Roubicek, *University of Arizona.*

Thirty steers were individually fed cottonseed hulls and supplemented in accord to body weight with five levels of dehydrated alfalfa compounded isonitrogenous with cottonseed meal for 110 days. The mg. of carotene per 100 lb. body weight furnished by the supplements were (1) 0, (2) 4.5, (3) 7.8, (4) 17.4, (5) 41.9. The following hepatic retention of vitamin A and carotene respectively were found (mcg. per gm.): (1) −13.2, −.8; (2) −7.1, 0.0; (3) +2.2, +1.2; (4) +5.7, +.9; (5) +6.8, +.5. The N.R.C. recommended allowance was approximately sufficient to maintain hepatic retention. No significant correlation between carotene intake and hepatic carotene storage or between hepatic vitamin A and carotene was found. These data show that the biological value of carotene decreased as the amount of carotene increased. The steers then were fed alfalfa hay that constituted an intake of 40.2 mg. carotene/100 pounds body weight for 18 days. Almost a complete reversal of hepatic retention found during the first period can be shown with the following storages of vitamin A and carotene (mcg. per gm.): (1) +5.2, +3.5; (2) −1.4, +2.1; (3) −6.3, +.3; (4) −3.6, +2.2; (5) −8.0, +.8. These data show that the biological value of carotene was dependent upon previous amounts of dietary carotene. Furthermore, that the homogenity of experimental animals are of primary importance in vitamin A-carotene investigations.

15. BOVINE SALIVA STUDIES. I. EFFECT OF COLLECTION METHOD ON PHYSICAL AND CHEMICAL PROPERTIES OF MIXED SALIVA. A. Dare McGilliard, H. G. Conner, C. W. Duncan and C. F. Huffman, *Michigan State University.*

Previous studies of mixed saliva have been made, for the most part, on orally collected samples. Visual observations of mixed saliva entering the rumen indicated that definite differences existed between the physical properties of oral and "cardial" saliva and it was assumed that corresponding differences probably existed in the chemical composition. Collection equipment was developed for aspiration of oral and cardial saliva either separately or simultaneously. A minimum of 5 oral samples and 5 cardial samples were collected from each of 2 Holstein cows with rumen fistulae which received hay as the only feed. Physical properties were determined on each individual sample immediately following collection. Chemical determinations were made on pooled samples. Collection rates of 231 and 191 ml. per min. were obtained for cardially collected saliva as compared to 53 and 40 ml. per min. for orally collected saliva, respectively. Cardially collected saliva was markedly more viscous (16–18 times), slightly lower in specific gravity and surface tension and slightly higher in pH and CO_2 combining power than orally collected saliva. Orally collected saliva was higher in dry matter, ash, urea nitrogen, phosphorus and potassium whereas cardially collected saliva was higher in total nitrogen, calcium, magnesium and sodium.

16. ESTIMATION OF RUMEN BLOOD FLOW IN CALVES USING ERYTHROCYTES TAGGED WITH PHOSPHORUS^{32}. H. R. Conrad, H. R. Smith, W. D. Pounden and J. W. Hibbs, *Ohio Agricultural Experiment Station.*

The rate of blood flow through the rumen, reticulum, omasum, a portion of the abomasum, and the spleen combined was estimated in five anesthetized calves. The abdominal cavity was entered by surgically removing the right 12th rib. The coeliac artery, which distributes blood to the forestomachs, was catheterized via the hepatic artery. The gastrosplenic vein was exposed and cannulated. Three ml. of blood cells previously tagged with P^{32} were injected intravenously into the coeliac artery and serial samples of venous blood draining the forestomachs and spleen were collected from the gastrosplenic vein for consecutive 2 second intervals for 2 minutes. The

tagged cells appeared in the gastrosplenic vein along a rising and falling curve from which the blood flow rate was calculated by the dilution method. Average length of time for the maximum radioactivity to appear in the gastrosplenic vein was 13.0 seconds. Calculated blood flow rate per 100 lb. of body weight was 516 ml. per min. Average total blood volume of the calves was 5.7% of the body weight. Serial blood samples were obtained from another calf at various intervals for 24 hours through a polyethylene catheter placed in the gastrosplenic vein and analyzed for volatile fatty acids. Using these data and the blood flow rate obtained from the anesthetized calves it was calculated that approximately 40 gm. of acetic acid were absorbed per pound of dry feed (a 2:1 mixture of alfalfa hay and grain) consumed during the 24 hour period.

17. NORMAL STANDARDS AND REPEATABILITY OF PHENOLSULFONPHTHALEIN FRACTIONAL CLEARANCE TEST FOR RENAL FUNCTION IN DAIRY CATTLE. R. R. Anderson and J. P. Mixner, *New Jersey Agricultural Experiment Station.*

Phenolsulfonphthalein (PSP) fractional clearance has been proposed previously as a measure of renal function in dairy cattle, and has been defined as that fraction of the total volume of distribution of PSP which is cleared of the dye per minute on an instantaneous basis after intravenous infusion. Studies were made on seven bull calves (mean body wt., 47.4 kg.) and twenty-one dairy cows (mean body wt., 596.2 kg.) to establish normal standards for and repeatability of the test in which every animal was subjected to the test on each of two successive days. The means and their standard errors, ranges, standard deviations, and the coefficients of variation of the PSP fractional clearance in the calves and cows, respectively were: 0.0277 ± 0.0029 and 0.0438 ± 0.0012; 0.0159 to 0.0533 and 0.0191 to 0.0656; 0.0109 and 0.0075; and 39.3 and 17.1%. The difference between the mean levels of the calves and cows was statistically highly significant. A components of variance study indicated that 65.0% of the total variance was associated with group (difference between calves and cows), 4.0% with animals within group, and 31.0% with error variance (comparison of determinations on two successive days). Based on error variance, the standard error of a single determination was 0.0080 and the coefficient of variation was 20.1%. The general accuracy and repeatability of the test was judged to be satisfactory.

18. EFFECTS OF EDTA AND PARATHYROID EXTRACT ON BLOOD CALCIUM LEVELS OF DAIRY CATTLE. H. D. Jackson, A. R. Pappenhagen and G. D. Goetsch, *Purdue University.*

The administration of ethylenediamine tetra acetic acid (EDTA) was used to evaluate the calcium mobilizing ability of dairy animals of various ages. When the EDTA (25 mg/kg) was injected during a two-minute period, the level of plasma calcium decreased 20–25% in the first 3 to 5 minutes, and then increased more slowly reaching 95% of the normal level in 2 hours. When this method was used, young cows and mature cows appeared to have equal calcium mobilizing ability. The slow injection of 65 gm. of EDTA per animal during a period of six hours offered a method by which the relative calcium mobilizing ability of animals of different ages could be determined. Two Holstein heifers (wt. 700 lb.) showed a decrease in plasma calcium of only 2.8 mg. % while two dry mature Jersey cows (ages 7 and 10, wt. 900 lb.) showed a decrease in plasma calcium of 4.4 mg. %. The calcium values of the heifers were normal four hours after the injection was completed while the calcium levels in the cows were well below normal. When parathyroid hormone (PTH, 400 or 800 units per 100 lb.) was administered 12 hours before the injection of EDTA, no beneficial effect was observed in preventing the drop in plasma calcium. However, in all animals the plasma calcium returned to normal more rapidly after the EDTA injection if PTH had been administered. The heifers were more resistant to the calcium depressing effects of EDTA and were more responsive to the calcium mobilizing effects of PTH than were the mature cows.

19. DISTRIBUTION OF ORAL AND INTRAVENOUSLY ADMINISTERED F^{18} IN CATTLE. C. C. Chamberlain, S. L. Hansard, C. S. Hobbs and Wise Burroughs, *University of Tennessee—AEC, Iowa State.*

Heifer calves 7–11 months old, and yearling heifers 17–22 months old were placed on caloric equivalent rations with NaF added to bring the fluorine levels to 0, 100, 300 ppm of fluorine. They were dosed orally and intravenously with F^{18} after fluorine feeding periods ranging from 32–55 days. Control calves and yearlings showed very low blood levels with orally administered F^{18} compared to those receiving 100 and 300 ppm of fluorine. Similar differences were apparent in the salivary and urinary levels of F^{18}. Peak levels in the blood appeared 2–4 hours after oral dosage. Intravenously administered F^{18} disappeared from the bloodstream similarly to intravenously administered Ca^{45} and P^{32}. Levels of F^{18} in the saliva and urine, up to six hours, showed similar curves to those in the blood. There were only small differences between calves and yearlings in the blood, plasma, salivary and urinary levels of F^{18} when intravenously administered. About 60–80% of the F^{18} in the blood was present in the plasma. There was about 2–4 times as much F^{18} present per gram of rib and femur epiphysis in the calves as in the yearlings, and a similar difference in the rib and femur shafts. Epiphysial levels of F^{18} were about 8–12 times as high as shaft levels. F^{18}, administered intravenously, was present in measurable quantities in the gastrointestinal tract tissues and contents, and in the bile, liver, kidney, spleen, and thyroid.

20. SOME EFFECTS ON SWINE OF ORALLY ADMINISTERED METHYL TESTOSTERONE. E. F. Johnston, J. H. Zeller and R. L. Hiner, *Animal Husbandry Research Division, Agr. Res. Center, Beltsville, Md.*

This is a summary of 5 experiments where methyl testosterone was fed at the rate of 15 mg. or 9 mg. per pound of feed in an attempt to determine its effects on growth, sizes of various organs and glands, and carcass characteristics. Little difference was noted in results from the two dosages of hormone. Methyl testosterone decreased rate of gain, daily feed consumption, feed efficiency, backfat thickness in 4 experiments, adrenal sizes in 3 experiments, and ovary and testicle sizes in intact animals. Feed consumption and efficiency data were analyzed in only one experiment. The other pigs were pen fed. In an experiment where the pigs were confined to metabolism cages where activity was practically nil, there was no significant differences in backfat thickness due to methyl testosterone. Under some conditions MT reduced sizes of adrenals and under other conditions no significant differences due to treatment were found. Methyl testosterone increased liver weights, kidney weights, and sizes of accessory sex glands in barrows. There was no objectionable odor due to methyl testosterone detected in the meat. Some interactions were found among breed, sex, feed, treatment, and other factors on carcass characteristics and rate of gain. Indications are that methyl testosterone increases the ratio of lean to fat in the carcass. The decrease in daily feed consumption could be due to unpalatability of the material or from other causes. This contributes to decreased feed efficiency.

21. A STUDY OF THE CAUSE OF THE SEXUAL ODOR IN THE BOAR. R. E. Christian and R. M. Turk, Jr., *University of Idaho.*

Eighteen male pigs, with an average initial weight of 136 lb., were assigned to six treatment groups with 3 pigs per group, as follows: I—untreated boars; II—untreated barrows; III—untreated boars from which the preputial diverticula were removed surgically prior to the start of the experiment; IV—boars castrated at the start of the experiment and which were injected subcutaneously with 10 mg. testosterone daily; V—boars fed 10 mg. stilbestrol daily; VI—boars fed 50 mg. stilbestrol daily. All animals were slaughtered after a 105-day experimental period. The average final weight was 291 lb. To determine the effect of treatment on the presence of the

boar odor and flavor, one-half of the loin from each animal was boned and roasted. A panel of 9 judges scored the samples for odor and flavor from 0–4, 0 being normal sweet and 4 being strong boar odor or flavor. The average scores for the animals from the six groups were for odor and flavor, respectively: I—2.4, 1.4; II—0.4, 0.5; III—1.5, 0.9; IV—1.0, 0.8; V—1.1, 0.7; VI—0.8, 0.5. The other one-half of the loin has been frozen and the test will be repeated in 3 months to determine the effect of freezing on the boar odor and flavor. There were no significant differences between lots in average rate of daily gain, weight of testes at slaughter, or concentration of epididymal sperm at slaughter.

22. HERITABILITY OF WEANING WEIGHT OF MILK LAMBS. Bruce L. Warwick and T. C. Cartwright, *Texas Agricultural Experiment Station, McGregor.*

Weaning weights of 1405 milk fat lambs born from the fall of 1952 through 1956 at McGregor were adjusted to 120 days of age for analysis. These were registered and unregistered Rambouillets, F_1 Rambouillet—Suffolk, and strains or lines which included breeding from the Rambouillet and one or more of the following: Dorset, Mouflon, Romney and very small fractions from some other breeds. Highly significant differences due to year born; season (fall or spring); sex; type of raising; breed, line or cross; and sire were found. Weaning weight ratios were computed for all lambs as follows: adjusted 120-day weight of lamb ÷ average adjusted 120-day weight of group, x 100. The group consisted of all lambs of the same sex and type of raising born in the same year and season. An intra-sire correlation based on weaning weights of 1281 lambs yielded a heritability estimate of 56%. Using weaning weight ratios, the intra-sire correlation among all lambs (1405) gave an estimate of 57%. Within each season, the following estimates were obtained: 0, 62, 0, 18, 64, 0, 71 and 36% respectively. The 0 estimates were from seasons having small numbers and non-significant differences due to sires. Regression of average offspring on parent gave the following heritability estimates: on mid-parent (105 pairs) 41%, on sire (19 pairs) 27% and on dam (123 pairs) 77%. These data indicate that heritability of weaning weight in lambs is high and that direct selection would be effective.

23. REPEATABILITY OF PERFORMANCE IN THE BEEF COW. J. C. Taylor, R. C. Carter, J. A. Gaines and C. M. Kincaid, *Virginia Polytechnic Institute.*

Blacksburg data on 330 calves (born 1949–54) from 103 unselected grade Hereford cows and sired by 38 registered bulls of Angus, Hereford, and Shorthorn breeding were available. Front Royal Station records on 900 calves (born 1950–56) from 364 registered Angus, Hereford and Shorthorn cows were available. Traits studied at both stations were birth weight, daily gain from birth to weaning and feeder grade at weaning; in addition daily gains and feeder grades from birth to midsummer were available in the Front Royal data. Blacksburg data were adjusted for effects of sex, breed of sire, and gain level of the sire by fitting constants. The Front Royal data were adjusted only for sex as it influenced birth weight and daily gain; the influence of sex on feeder grade was negligible. Methods used for estimating repeatability were intraclass correlation, regression and correlation of second and also average of subsequent records on record of first calf and regression of second records from the first toward the herd average. Estimates of 0.18 for birth weight, 0.30 for weaning gain, and 0.27 for weaning feeder grade were obtained from the Blacksburg data. Repeatability of birth weight in the Front Royal herd was of the order of 0.30 for all three breeds; that of gain from birth to midsummer was 0.50 for the Herefords, 0.36 for Angus and Shorthorn; it was 0.30 for feeder grade in all breeds at midsummer and at weaning, with the exception of Angus at weaning, in which case repeatability of grade was 0.07. Production records prior to weaning appear to be a reliable basis for selection.

24. A GENETIC ANALYSIS OF LONG YEARLING HEIFER WEIGHTS IN A RANGE BEEF HERD OPERATED UNDER OPTIMUM AND SUB-OPTIMUM NUTRITIONAL REGIMES. K. A. Wagnon and W. C. Rollins, *University of California.*

A genetic analysis has been made of 335 long yearling heifer weights collected in two experimental range herds, A and B, of similar breeding that were managed alike except that in herd A the heifers were supplemented during the fall and winter (post weaning) when the range was nutritionally deficient, while the heifers in herd B were not supplemented. Heritability of long yearling weight was estimated to be .48 for herd A and —.35 for herd B. A genetic correlation of .71 and an environmental correlation of .67 was found between weaning weight and weaning grade in herd A while for herd B these were zero and .94 respectively. Since in paternal half sib estimates of heritability and genetic correlation, dominance effects occur statistically in the term for random environmental effects it is felt that these estimates considered jointly suggest a greater importance for heterozygosity and a lesser importance of additively genetic effects under B herd than under A herd conditions. In herd A, a heifers weaning weight and long yearling weight were correlated with her subsequent production (weaning weight of her calves) .16 and .36 respectively. In herd B these correlations were —.06 and .01 respectively. The heritability estimates and the other statistics given above support the hypothesis that more effective selection for replacement heifers can be made in herds operated under an optimum nutritional regime than in those operated under a sub-optimum nutritional regime.

25. THE RELATIONSHIP OF INHERITANCE TO TENDERNESS OF THE MEAT OF YEARLING STEERS. T. C. Cartwright, Sylvia Cover and O. D. Butler, *Texas Agricultural Experiment Station.*

The tenderness of the meat from 49 steers which were approximately 15 months of age, raised at McGregor and slaughtered at College Station was measured in the Food Research Laboratory of the Home Economics Dept. Represented were Hereford (H); Brahman (B); F_1, ½H–½B (B sires); backcross, ¾H–¼B; and backcross, ¾B–¼H; from 5 Hereford and 6 Brahman sires. Loins and bottom rounds were cooked by broiling to 61° C. and 80° C. and by braising to 85° C. and 100° C. Four judges scored the meat for softness, friability and connective tissue. Mechanical shear force values were obtained. Of the 8 possible "temperature and cut" categories the number with significant differences due to breed of sire was as follows: softness, 1; friability, 2; residual connective tissue, 0; and shears, 3. The number of significant differences due to sires within breeds was as follows: softness, 3 for Brahman sires; friabiilty, 2 for Brahman sires; residual connective tissue, 4 for Brahman sires and 2 for Hereford sires; and shears, 1 for Brahman sires. Earlier work indicated high but variable heritability estimates for shears and tenderness scores based on similar small numbers. This work continues to indicate that the heritability of certain eating quality characters may be of a magnitude to allow effective selection. There was more variability among the Brahman sire groups than among the Hereford sire groups. Progeny of some Brahman sires equalled or excelled in tenderness those of some Hereford sires, but this was not true for all Brahman sires. More work is needed to establish a basis for selection of tenderness of beef.

26. SOME FACTORS AFFECTING THE EFFICIENCY OF FEED UTILIZATION OF BULLS ON GAIN EVALUATION TEST. C. J. Brown, Maurice L. Ray and Warren Gifford, *University of Arkansas.*

Two young bulls from each of six sire groups that had completed a 154 day gain evalaution test were selected at random and placed in digestion stalls. A ration of one-third chopped prairie hay and two-thirds grain mix was fed throughout the gain test

and the digestion trial. Feed, feces and urine collections were made during a seven day period from which digestibility of dry matter, crude protein, crude fiber, ether extract and nitrogen-free extract were determined by standard procedures. The six sire groups consisted of three Hereford groups and three Aberdeen-Angus groups of different bloodlines within each breed. The range of sire differences in digestibility was, from 64.8 to 71.8 for dry matter; from 65.3 to 73.3 for crude protein; from 47.9 to 58.3 for crude fiber; from 64.6 to 76.8 for ether extract; from 72.4 to 76.1 for nitrogen-free extract. Phenotypic correlations among these six sire groups ranged from .22 for digestibility of dry matter to .66 for digestibility of crude protein. Digestibility of dry matter was correlated with feed lot gain (—.58) and feed consumption (—.60). Other correlations of feed lot performance and digestibility of feed nutrients were not significant.

27. BODY MEASUREMENTS IN RELATION TO BEEF CARCASS CHARACTERISTICS. G. M. Tallis, Earle W. Klosterman and V. R. Cahill, *Ohio Agricultural Experiment Station.*

As a preliminary investigation, ten linear body measurements were taken in duplicate on eight Hereford steers by two investigators. The components of variance due to steers, investigators, steer and investigator interaction and measurement error were estimated and compared. Results of this study indicated that heart girth, circumference at navel, length of body, width of chest, depth of chest and height at hooks and withers had the highest steer components and the lowest investigator, interaction and error components. Measurements were then obtained on three groups of Hereford cattle, each group representing a different type of breeding. Nine ratios involving live weight and linear measurements were calculated and correlated with dressing percentage, area of rib eye and edible portion. From a study of the first breeding group, the two ratios weight/height and weight/length showed most promise of predictive value. Therefore, these were the only ratios which were calculated for the other two breeding groups. Zero order correlations were computed separately for steers and hiefers and corrections were made for differences between breeding groups. In both the steer and the heifer data, the two ratios were positivly correlated with area of rib eye ($P<.01$) and negatively correlated with edible portion ($P<.05$). In the case of steers these ratios were positively correlated ($P<.01$) with dressing percentage. However, the correlations of heifer ratios with dressing percentage were not significant. A total of 64 heifers and 59 steers were used in this study.

28. CROSSBRED BEEF CATTLE IN THE GULF COAST REGION. R. A. Damon, Jr., S. E. McCraine and R. M. Crown, *Louisiana State University.*

An extensive crossbreeding program was initiated in 1952 to determine what types of beef cattle are adapted best to the conditions in the Gulf Coast Region. Six herds of 32 cows each, composed of 8 Angus, 8 Brahman, 8 Brahman-Angus, and 8 Hereford cows, were bred to bulls of 6 different breeds. Bulls of the Angus, Brahman, Brahman-Angus, Charolaise, Hereford, and Shorthorn breeds were used. A new bull was selected annually to represent each of the breeds, and the cow herds were rotated so that purebred and crossbred calves were produced by different cows and different bulls each year. This breeding plan resulted in the production of 24 different types of cattle. Weaning weights and grades are two of the principal criteria of evaluation. The data resulting from this work show that calves raised by Brahman-Angus and Brahman cows are considerably heavier than those raised by Angus and Hereford cows. The calves sired by Charolaise, Shorthorn, and Hereford bulls have been heavier at weaning than those sired by Brahman, Brahman-Angus, and Angus bulls. Weaning grades have corresponded closely with weaning weight. The steer calves have been fed out after weaning

on wheat and rye grass pasture with a grain supplement. The calves raised by Hereford and Angus cows gained more rapidly than those raised by Brahman and Brahman-Angus cows. The calves sired by Charolaise, Shorthorn, and Hereford bulls gained more rapidly than those sired by Angus, Brahman, and Brahman-Angus bulls.

29. THE VALIDITY OF DWARF-CARRIER COWS AS TESTERS FOR THE MAJOR DWARF CONDITIONING GENE. P. W. Gregory, L. M. Julian and W. S. Tyler, *University of California.*

Matings at this station indicate that bovine dwarfism is a complex of several components rather than a single entity, and that each component is homozygous for the same autosomal recessive dwarf conditioning gene. Specific modifying genes, or combination of modifiers, are responsible for differentiating individual dwarf types. Comprest, and dwarfs of brachycephalic, doliocephalic, intermediate, and other types belong to the complex. Progeny testing for the major dwarf conditioning gene may prove invalid if test progeny are classified only into brachycephalic dwarfs and normal. A Hereford bull was progeny tested in three ways. First, he was mated to comprest type cows from dwarf-carrier stock. Two brachycephalic dwarfs proved him a carrier. Next, he was progeny tested on brachycephalic dwarf cows. Four progeny from this were classified as 1 brachycephalic dwarf, which had a complete fusion of the sphenoid and occipital bones at five weeks, and 3 intermediate dwarfs. Third, he was progeny tested on proven dwarf-carrier cows of normal size. The 23 progeny were classified as 15 normal, 4 comprest, 3 intermediate dwarfs, and 1 dwarf as yet unclassified. Under ranch conditions the brachycephalic dwarf would have been recognized. The comprest and intermediate dwarfs would have been classed as normal. The unclassified stillborn dwarf would have been disregarded even though the intersphenoid and occipital bones were completely fused. These tests support results from other matings that other genes present in cattle of normal or near normal size mask or modify the expression of the major dwarf conditioning gene, and thus confuse the progeny test.

30. ANATOMICAL MEASUREMENTS AS RELATED TO THE SNORTER DWARF GENE IN HEREFORD CALVES. R. L. Arthaud, R. M. Koch and V. H. Arthaud, *U.S.D.A. & University of Nebraska.*

Body measurements (mm.) were obtained within a week after birth from 95 calves with clean pedigrees (46 bulls, 49 heifers) and 29 calves heterozygous for the snorter dwarf gene (13 bulls, 16 heifers). Adjustments were made for differences in birth weight. Mean differences in measurements (mean for pedigree clean less mean for carrier) for each sex were: (differences in males listed first) cannon bone length, 3.35 and 4.09; cannon width, —2.01 and —2.18; length of first five lumbar vertebrae, 2.27 and —1.56; cannon length/cannon width, 0.53 and 0.64; cannon length/cannon circumference, 0.08 and 0.07; cannon circumference, —4.36 and —3.31; and cephalic index, 0.06 and 0.04. The first three of these measurements were made from x-ray radiographs. All of these differences were highly significant ($P<0.01$) except cephalic index ($P<0.05$) and lumbar vertebrae length ($P>0.05$). Discriminate functions for males ($Y_m=0.100$ birth weight $+0.492$ cannon length -1.941 cannon width $+3.383$ cephalic index) and females ($Y_F=-0.010$ birth weight $+0.226$ cannon length -0.581 cannon width $+5.276$ cephalic index) were obtained from these data. When these functions were applied to the same population the overlap between pedigree clean and carrier calves was 37 percent for males and 38 percent for females. The functions were applied to data from 69 x-rayed offspring of carrier parents. The overlap between calves with B-type (abnormal) vertebrae and calves with C-type (normal) vertebrae was 79 percent for males and 24 percent for females.

31. THE EXPRESSION OF VARIOUS FORMS OF DWARFISM IN CERTAIN CROSSES AND HETEROGENEOUS GENETIC BACKGROUNDS IN BEEF CATTLE. J. C. Dollahon, M. Koger, J. F. Hentges and A. C. Warnick, *University of Florida.*

Results from dwarf x dwarf, dwarf x carrier and carrier x carrier matings were: (1) A snorter Hereford x snorter Angus produced a snorter dwarf, which indicates the same gene is present in both breeds. (2) An atypical dwarf resulted from mating a snorter Hereford and a long-headed Shorthorn. (3) When the snorter trait was introduced into a Brahman—Native—European crossbred population the offspring produced were more compact than offspring obtained from similar dams and normal males. (4) Two types of dwarfs were observed in a herd of carrier Herefords, a long-headed type and the conventional snorter types. The two types showed certain similarities in that each exhibited hydrocephalus and compressed vertebrae. A long-headed Hereford bull from another source was mated to dwarf females of various types. These matings produced only normal offspring, indicating this animal was a nutritional dwarf or carried a gene which was not present in the dwarf females. (5) Apparently the midget in Brahmans is inherited as an incomplete dominant or a recessive trait. The offspring from two midget x midget matings were midgets. A midget Brahman x long-headed Angus mating produced a dwarf which was similar to the midget, but appeared less viable. The mating of a midget Brahman and a snorter Hereford produced a stillborn offspring, which on anatomical classification was a snorter dwarf. (6) The guinea condition in Florida crossbred and native cattle appears to have descended from the Dexter. Both guinea x guinea and snorter Hereford x guinea matings produced guinea offspring.

32. QUANTITATIVE CHEMICAL AND GRANULOCYTIC CHANGES IN INSULIN INDUCED STRESS IN MATURE DWARF BOVINE AND HETEROZYGOTE FEMALES. Charles W. Deyoe, Myrtis C. Shrode, William C. Banks and H. O. Kunkel, *Texas A. and M. College System.*

Blood glucose and plasma free glutamic acid, glycine and histidine have been determined in association with insulin induced stress in dwarf and normal animals. No significant differences in the responses were detected. Total leucocyte counts, using 0.1 N HCl as the diluent, and differential white cell counts were made following the injection of crystalline zinc insulin. Under the conditions of these tests, significant increases after two hours in total leucocytes were obtained in the heterozygote or dwarf carrier animals and dwarfs, but not in animals from a herd in which there has been no incidence of dwarfism. Differential counts and calculations indicate the only changes occur in granulocytes with an increase in neutrophiles and a slight decrease in eosinophiles. Seasonal differences in the response may exist. The capacity of the plasma to oxidize dimethyl paraphenylenediamine (DPP) varies inversely with the initial leucocyte count but is not affected by insulin treatment in either normal or carrier cows.

33. A COMPARISON OF THE BLOOD COMPOSITION AND PHYSIOLOGY IN BRAHMAN AND BRITISH CATTLE. J. R. Howes, J. F. Hentges, Jr., A. C. Warnick and T. J. Cunha, *Florida Agricultural Experiment Station.*

Twelve Herefords and 12 Brahman yearling heifers averaging 650 lb. were allocated into two treatment groups which respectively received 100 and 50% of the N.R.C. recommended protein allowances. Criteria studied included live weight gains, red and white blood cell counts, hematocrit, hemoglobin, mean corpuscular volume, mean cellular hemoglobin, plasma protein, blood volume, blood oxygenating capacity and carbon dioxide content, frequency and duration of estrus and various indicators of heat tolerance. During the February to July period, the Herefords on the two protein

levels gained 0.22 and 0.17 lb. per day, respectively, faster than the Brahmans which exhibited greater red and white blood cell counts, hematocrit, hemoglobin and mean corpuscular volumes. Data gathered from 50 other Herefords and Brahmans of varying age strongly support these species differences, but the red blood cell concentration was shown to decline with age in both species. The mean cellular hemoglobin and plasma protein data showed no significant differences between either species or protein level. The blood volume as assessed by the T1824 dye method indicated a higher volume per unit of live weight for the Brahmans. Adrenline and tranquilizers injected intravenously into both species on a body weight basis showed that Brahmans require more tranquilizer to become docile. For 42 days, the 24 heifers were checked with vasectomized bulls for reproductive activity every two hours. Several Brahmans never exhibited any signs of estrus although by palpation their ovaries were known to be active. The Herefords exhibited greater variability in estrous cycles.

34. RELATIONSHIP BETWEEN SERUM PROTEIN BOUND IODINE AND OTHER BLOOD CONSTITUENTS TO RATES OF GAIN IN BEEF CATTLE. H. O. Kunkel, George G. Green, John K. Riggs, R. L. Smith and Myrtis C. Shrode, *Texas Agricultural Experiment Station.*

Determinations of serum protein-bound iodine (PBI) have been made on over 500 beef calves in gain evaluation tests. Preliminary results had indicated that the PBI was related to rates of gain in a curvilinear manner. After extensive studies, however, it does not appear that PBI in itself will account for a large amount ($<20\%$) of the variance in rates of gain. Breed differences may exist in the relationship between PBI and rates of gain. A curvilinear correlation may exist, but has been verified in only a few groups of animals. Preliminary studies of the data indicate that variation in the blood, glutathione, hemoglobin, serum globulin and alkaline phosphatase levels may be related to factors affecting the PBI-gain relationship.

35. GENOTYPE DIFFERENCES IN THE MELANIN CONTENT OF CATTLE HAIR PARTITIONED BY VARIOUS SEQUENCES OF ALKALINE AND ACID HYDROLYSIS. R. G. Washburn, L. O. Gilmore and N. S. Fechheimer, *Ohio Agricultural Experiment Station.*

Cattle hair was partitioned into 16 fractions using a different sequence of acid and alkaline hydrolysis, in a further attempt to diagnose black cattle carrying the red factor. In four experiments using different time durations of extraction, the yield of material in five fractions was greater from red hair than from black. In five different fractions the yield was less from red than from black hair. In these five fractions red and black hair gave the same relative yields as was found with acid insoluble melanin which has been previously reported. One of these five fractions i.e. No. 15 (the acid precipitate from an original alkaline hydrolysate) checks closely with the yield from the acid insoluble fraction. In two of these fractions, including No. 15, the black non-carrier has a higher yield than the carrier. Excluding fraction No. 15, there remains one new melanin fraction being tested for its diagnostic value to distinguish carrier from non-carrier black cattle in artificial breeding programs.

36. THE PROFIT LIES IN CHOICE CATTLE. John S. Robinson, *University of Tennessee.*

Results of 1956 surveys made with Tennessee packers and larger meat merchandising stores show that the housewife prefers beef with less waste fat than the prime grade. Records show that under Tennessee conditions, choice cattle usually are more apt than prime to make a profit. For these reasons, added emphasis was placed on cattle of the choice grade in this spring's Chattanooga and Knoxville shows. In those

two events, all cattle were graded, then equal prize money was awarded to choice and prime animals; (a) by grade, (b) by placings in the junior halter show. At Chattanooga there were 115 calves in the junior halter classes and at Knoxville 153. The auction sale order was arranged so that all first-place prime and choice calves sold first, then all second place, and so on. Choice cattle sold for an average of 28 cents per pound, while prime cattle averaged only 1 cent per pound more than that. Cattle grading good sold for an average of 23 cents. Therefore, in sales of junior project calves, packers and meat merchandisers indicate a preference to feature calves of choice finish.

37. PERFORMANCE TESTING AND MARKETING HOGS ON GRADE BASIS. J. K. Butler, Jr. and Jack Kelley, *North Carolina State College.*

Marketing hogs on a grade basis in North Carolina began with 4-H Fat Stock Shows and Special Demonstration Sales in 1954. These sales followed three years of a meat type hog educational program consisting of live hog grading demonstrations and carcass cut out demonstrations with farmer groups. On June 1, 1955 one packing plant began buying hogs on a modified grade basis which did not discount US No. 3 hogs. Since that time 16 buying stations have initiated a similar program and 9 Stations are buying hogs on a strict grade basis which discounts US No. 3 hogs. It was felt that Performance Testing and Marketing hogs on a grade basis should go hand in hand because these programs compliment each other. Pure-bred swine breeders and North Carolina packers have cooperated in this meat hog certification program. Packers have become more conscious of the differences in carcass value between different live hogs while purebred and commercial swine breeders have found the program valuable in their selection of breeding stock. These activities have resulted in closer cooperation between packers, purebred breeders, commercial hog men, the North Carolina Department of Agriculture and Extension personnel in the State.

38. ABSORPTION OF DIETHYLSTILBESTROL IMPLANTS IN STEERS. W. H. Hale, W. C. Sherman, E. A. White, G. Kuhn, W. M. Reynolds and H. G. Luther, *Chas. Pfizer & Co., Inc., Terre Haute, Ind.*

Each of 24 steers was implanted with two 12 mg. pellets of diethylstilbestrol (stilbestrol). Implantations were made subcutaneously about half way between the tip and base of one ear. Pellet residues were removed from six randomly selected steers at 28, 56, 84 and 112 days subsequent to implanting. The average residue of stilbestrol at 112 days was 4.26 mg. per pellet. The half life of a pellet was calculated to be 63 days. There was no evidence of rapid absorption or encapsulation of the implants. The average daily absorption rate was 74 mcg. stilbestrol per pellet over the 112 day period. The rate of absorption was a first order reaction characterized by the following exponential equation, $Y=0.848ae^{-0.00841t}$, where Y=mg. stilbestrol found, a=mg. stilbestrol implanted initially and t=time in days. It is concluded that a single implantation of two or three 12 mg. stilbestrol pellets will exert its growth-promoting effect for a 150–200 days feeding period.

39. STILBESTROL IMPLANTS FOR YEARLING CATTLE GRAZED ON NATIVE SUMMER RANGE. O. O. Thomas, R. R. Woodward, J. R. Quesenberry and F. S. Willson, *Montana Agricultural Experiment Station and U. S. Range Livestock Exp. Station.*

Four trials involving 364 yearling steers and spayed heifers were conducted to determine the weight-gain response of cattle implanted with various levels of stilbestrol and grazed on native range during the summer. All cattle were eartagged and

individually weighed. *Trial I.* Eighty-eight yearling Hereford steers were implanted with levels of 0, 12, 24, or 36 mg. of stilbestrol and weighed on May 23, 1956. The steers were grazed on native range and weighed off the experiment on September 19, 1956. The average daily gains for the 0, 12, 24, and 36 mg. stilbestrol treatment was 1.27, 1.49, 1.65, and 1.47 lb., respectively. *Trial II.* One hundred-twenty Hereford yearling steers implanted with stilbestrol at levels of 0, 12, 24, or 36 mg. and grazed on native range from May 15 to October 12, 1956, gained 1.75, 2.01, 1.94, and 1.99 lb. per day, respectively. *Trial III.* Ninety spayed beef heifers implanted with stilbestrol at levels of 0, 6, 12, 18, 24, or 30 mg. and grazed from May 23 to September 19, 1956, gained 0.83, 0.93, 1.18, 1.26, 1.16, and 1.06 lb. per day, respectively. *Trial IV.* Sixty-six yearling Hereford steers implanted with stilbestrol at levels of 0, 30 or 60 mg. and grazed on native range from May 4, to October 18, 1957 gained 2.04 lb., 2.29 lb., and 2.27 lb. per day, respectively. Differences in gain among lots were significant ($P<0.01$) in all four trials. Results of experiments currently in progress involving 800 steers implanted with stilbestrol at various levels and grazed on native range will be presented.

40. EFFECT OF DIETHYLSTILBESTROL IMPLANTATION AND CHLORTETRACYCLINE ON GAINS AND BLOOD COMPONENTS OF BEEF CALVES AND GAINS AND ESTRUS OF YEARLING HEIFERS. W. D. Fletcher, J. F. Hentges, Jr. and T. J. Cunha, *Florida Agricultural Experiment Station.*

In Experiment I, forty, 240-lb. utility and cull summer calves, typical of those which flood the Southeastern fall markets, were fed for 70 days on a high concentrate ration with the following chlortetracycline (Aurofac-10) supplementations: I, none; II, 25 mg.; III, 75 mg. and IV, 75 mg. for initial 42 days. Five calves in each lot were implanted with 24 mg. diethylstilbestrol (DES). Average rates of gain for non-implanted and implanted calves (in parentheses) were: I, 1.98 (2.04); II, 1.52 (2.03); III, 1.44 (2.23) and IV, 1.45 (1.72). Gains were significantly increased with DES implants. The DES-75-mg. chlortetracycline treatment produced the fastest gains. No consistent differences in hemoglobin, hematocrit, non-protein nitrogen or plasma vitamin A were detected. Experiment II; Thirty-three purebred replacement heifers, 12 to 14 months of age, were fed 63 days on a high roughage ration with the following chlortetracycline supplementations: I, none; II, 25 mg. and III, 75 mg. Four heifers in each lot received a 24 mg. DES implant. Average daily gains for non-implanted and implanted heifers (in parentheses) were: I, 1.50 (1.73); II, 1.59 (1.70) and III, 1.38 (2.03). Highly significant increases in rates of gain were produced by DES implants, while the DES-75 mg. chlortetracycline treatment produced the fastest gains. Implanted heifers exhibited excessive mucous secretions and prolonged estrus but no indications of vaginal prolapse. All lots were continued on pasture without supplementation for visual observations on frequency of estrus and periodic rectal palpation.

41. SYNOVEX AND STILBESTROL IMPLANTS FOR WINTERING AND FATTENING BEEF CALVES WITH REIMPLANTATION EFFECTS. N. W. Bradley, G. E. Mitchell, Jr., W. W. Albert, A. L. Neumann and J. L. Williamson, *University of Illinois.*

Two feeding trials have been conducted to compare synovex and stilbestrol implants in Hereford steer calves fed high silage fattening or wintering rations. A third trial is being conducted to study the effect of implanting wintering calves on their performance during subsequent full-feeding with and without additional implants. Average daily gains for groups of 16 steer calves fed fattening rations for 196 days were 2.05, 2.20, and 2.30 lb. for control steers, steers receiving 36 mg. stilbestrol implants, and steers implanted with synovex respectively. Hormone treatments did not

affect live slaughter grade. Average daily gains for groups of 12 steer calves fed wintering rations for 154 days were 1.72, 1.86, and 2.03 respectively for the same treatments. Immediately prior to being given access to self-feeders on legume pasture steers from the wintering trial were realloted so that 6 steers received each of the following treatments: no implant, 36-mg. stilbestrol implant before wintering, 36-mg. stilbestrol implant before wintering and reimplanted with 36 mg. of stilbestrol, synovex implant before wintering, and synovex implant before wintering and reimplanted with synovex. Average daily gains for 84 days were 2.20, 2.40, 2.68, 2.62 and 2.42 respectively. After 112 days on pasture these steers will be finished in dry lot.

42. THE EFFECT OF DIFFERENT FEEDING REGIMENS ON THE RESPONSE OF GROWING-FATTENING LAMBS TO ESTRADIOL-PROGESTERONE IMPLANTS. Ronald R. Johnson, D. S. Bell and O. G. Bentley, *Ohio Agricultural Experiment Station, Wooster.*

Implants of the combination of estradiol and progesterone have been tested for their effect on rate of gain, carcass quality and feed efficiency in growing-fattening lambs on different feeding regimens. In three trials involving 81 lambs at an average starting weight of 70 lb., the hormone implant markedly increased rates of gain (average of 34%) and improved feed efficiency (average of 22%). Live grades and carcass grades were similar for the implanted and the control lambs—all lambs selling for the same price. Using levels of 4 mg. estradiol and 160 mg. progesterone, implanted wether lambs exhibited some teat swelling but no prolapse of the rectum or urinary tract blockage. Implanted ewe lambs showed mammary development, teat elongation, and some swelling of the vulva but no prolapse. A comparison of low and high grain feeding showed that the hormone implant produced a favorable response on either level of feeding. Eighteen wether lambs implanted prior to weaning (at weight of 47 lb.) showed a rate of gain response to the implant in the pre-weaning period but the greatest benefit was observed after the lambs were on full grain feeding. The level of hormone used in this experiment (3.3 mg. estradiol benzoate and 200 mg. progesterone) appeared to be effective over the 147 day test period.

43. THE EFFECT OF DIETHYLSTILBESTROL UPON GAINS, BONE GROWTH, BONE COMPOSITION, AND CALCIUM, PHOSPHORUS AND NITROGEN METABOLISM OF LAMBS FED TWO LEVELS OF PROTEIN. Allen D. Tillman and J. R. Brethour, *University of Tennessee—Atomic Energy Commission Agr. Res. Program.*

Twenty-eight lambs were divided into 4 lots and fed two levels of protein (6 and 10%), with one lot on each level receiving orally 3 mg. of diethylstilbestrol daily. Growth and feed efficiency data were obtained on all animals. At the beginning of the 56-day trial 3 animals from each lot received intraperitoneally 1 millicurie of calcium —45 for measuring bone growth by autoradiograms. One month after the feeding test began, the remaining 4 animals in each group were used in a metabolism trial. After a 7-day preliminary period in metabolism units, concurrent 7-day chemical and radiochemical studies were made using, simultaneously, calcium-45 and phosphorus-32. Digestibility of dry matter, organic matter, and nitrogen as well as the retention of nitrogen was determined on all metabolism animals. When out of the metabolism units, all animals were individually-penned and fed *ad libitum*. Feed consumption was determined daily and, based upon the feed consumption during the previous day, the calcium and phosphorus intakes were equalized by the addition, where needed, of analytical grade dicalcium phosphate. Diethylstilbestrol added to the 6% protein ration apparently decreased gains, as well as the utilization of nitrogen, chemical and radiochemical calcium and phosphorus. When added to the 10% protein ration, diethylstilbestrol apparently increased gains, feed efficiency and the utilization of phosphorus. The effects on calcium and nitrogen metabolism were not consistent. Consideration of the results as they relate to the mechanism of action of diethylstilbestrol will be given.

44. TIME, DIETHYLSTILBESTROL AND VITAMIN B_{12} IN THE ADAPTATION OF LAMBS TO NPN UTILIZATION. J. A. Welch, G. C. Anderson, G. A. McLaren, C. D. Campbell, and G. S. Smith, *West Virginia University*.

In the course of evaluating several NPN compounds as nitrogen supplements for lambs, it became apparent that nitrogen utilization was influenced by the length of the preliminary adjustment period. In this report, various factors influencing this adaptation will be considered. Semi-purified rations containing 1.7% nitrogen (two-thirds of which was supplied by urea, crude biuret or a 2:1 mixture of urea and creatine) were fed to wether lambs during preliminary periods ranging from 10 to 50 days. After the varying periods of adjustment they were placed on standard 10-day digestion and nitrogen metabolism trials. When diethylstilbestrol (DES) or vitamin B_{12} was added to these rations, it was at the level of 2 mg. and 10 mcg. respectively per day. Lambs on the urea ration received either no supplement, DES or vitamin B_{12}. One-half of the lambs fed crude biuret received DES, and one-half of those fed the creatine ration received vitamin B_{12}. Utilization of nitrogen of the three NPN sources increased as a function of the length of the preliminary period, reaching maximum values after 35 days. DES reduced the period of adjustment required for maximum utilization of urea and crude biuret nitrogen to 10 days, but did not change the apparent digestibility of nitrogen. Vitamin B_{12} did not influence the utilization of urea nitrogen, but increased the utilization of creatine nitrogen after a 10-day preliminary period. Apparent digestibility of nitrogen of the creatine ration was increased as the result of vitamin B_{12} supplementation.

45. INFLUENCE OF VARYING PROTEIN AND ENERGY LEVELS UPON THE STILBESTROL RESPONSES IN FATTENING LAMBS. Rodney L. Preston and Wise Burroughs, *Iowa State College*.

Three levels of oral stilbestrol (0, 0.3, and 0.6 mg. per lb. of ration), three levels of protein (9, 13, and 17% protein in total ration), and two levels of energy (530 and 665 ENE Calories per lb. of ration) were fed wether lambs in studying growth response, feed utilization and carcass evaluations. Stilbestrol stimulated gains ($P<.01$) in all ration combinations except the high protein-low energy ration. The average stimulation was 23%. The greatest stimulation occurred on the high vs. low energy rations. On the high energy ration, greater stimulation was noted on the high protein ration, whereas, on the low energy ration the reverse was true. Feed efficiency reflected reciprocal changes. Live and carcass grades were increased by the high vs. low energy rations; effects of stilbestrol and protein were not significant. Dressing percent was increased by the high energy and high protein rations, and decreased by stilbestrol. Changes in the percent of separable fat in the rack were noted; only the increase observed on the high energy ration proved statistically significant. When the changes due to stilbestrol were plotted on a Calorie (ENE) to protein ratio, a correlation coefficient of 0.87 ($P<.01$) was found. From the regression equation, $Y=.139X-7.85$ (Y=change in separable fat percentage from controls, and X=Cal. to protein ratio), it was found that stilbestrol feeding did not alter the percent of separable fat when a ration containing a Cal-protein ratio of 56 was fed. Above this ratio stilbestrol increased fat deposition while a lower ratio increased leanness. Fat determinations on the longissimus dorsi M. showed a similar but less consistent trend.

46. SOME EFFECTS OF TETRA ALKYLAMMONIUM STEARATE (DYNAFAC) AND DIETHYLSTILBESTROL ON PERFORMANCE OF FATTENING STEERS. I. A. Dyer and John McGregor, *State College of Washington and McGregor Land and Livestock Company*.

One hundred twenty yearling steers were divided into six groups of 20 each and self-fed for 71 days. Group one was fed a ration composed of 45% barley, 17% cull

peas, 7.5% beat pulp, 5% molasses, 0.5% salt and 25% alfalfa. Groups 2 and 3 received an identical ration and were implanted with 36 mg. stilbestrol per steer. Group 4 was fed the same ration as group 1 plus 2 gm. Dynafac per steer daily. Groups 5 and 6 were fed the same ration as group 4 and were implanted with 36 mg. stilbestrol per head. Average rates of gain for group 1–6 were 3.0, 3.4, 3.5, 3.5, 3.6 and 3.7 lb. per day, respectively. An increase occurred in daily gain of .3 pound per steer for the Dynafac and stilbestrol when administered singly and .6 pound when both treatments were given. The efficiency of feed utilization was highest in group 6 and lowest in group 1.

47. EFFECT OF LEVEL OF FEED INTAKE ON STEERS FED CHLORTETRACYCLINE AND/OR DIETHYLSTILBESTROL ON PASTURE AND IN DRYLOT. H. L. Chapman, Jr., R. W. Kidder, A. Z. Palmer and John Emerson, *Everglades Experiment Station, University of Florida.*

One hundred thirty-six grade, two-year old steers were divided into 17 lots of 8 animals each and fed for a 142-day period, from November 1956 to March 1957, to determine the effect of two different levels of concentrate feed intake upon the feeding value of 90 mg. of chlortetracycline per head daily and/or 10 mg. of diethystilbestrol per animal daily for steers fattened on pasture as compared to drylot; and the value of orally administered diethylstilbestrol as compared to stilbestrol implants for cattle fattened on pasture. Diethylstilbestrol was implanted at the rate of 36 mg. per animal at the beginning of the experiment. Animals on limited feed received 6 lb. daily of a concentrate feed of ground snapped corn, citrus pulp, 41% cottonseed meal, urea and cane molasses. This mixture was fed *ad lib* to full-fed groups. The principal beneficial effect of orally administered diethylstilbestrol was realized by steers full-fed, in drylot. Steers receiving chlortetracycline, on pasture, had approximately 14% less gain, on both levels of feed intake, as compared to steers receiving the basal ration. A combination of antibiotic and stilbestrol increased gains except for limited fed steers on pasture. Stilbestrol implants did not increase average daily gain of steers full-fed on pasture as compared to those receiving the basal ration. Average daily gain was higher for cattle fattened on pasture than in drylot, on each level of feed intake.

48. THE EFFECT OF HYGROMYCIN A IN LAMB FATTENING AND DIGESTION STUDIES. J. W. Stroud, F. H. Baker and R. B. Grainger, *University of Kentucky.*

Forty wether lambs were employed in a 45-day fattening trial to determine the effect of Hygromycin A on a pelleted ration. The basal ration (Lots I, III, V and VII) contained ground corncobs (50.0%), hydrol, red dog flour, ground corn, soybean meal, NaCl, $CaCO_3$, KI, $CoSO_4$, and vitamins A and D. Hygromycin A added to the basal at the rate of 5 mg./lb. of feed constituted the treatments in Lots II, IV, VI and VIII. A 37-day digestion trial (2x2 factorial) using 16 wethers was conducted in conjunction with the feed lot observations to resolve the effect of Hygromycin A on the digestibility of the basal ration and the influence of method of feeding (limited: 700 gm./day vs. self-fed: avg. 1754 gm./day) on the digestibility of the basal and antibiotic rations. The results of the feeding trial in terms of average daily gain, average daily feed intake and average lb. of feed/lb. gain, were 0.27, 3.88, 14.30 and 0.35, 4.41, 12.48 for the 4 basal and 4 antibiotic lots, respectively. The addition of Hygromycin A significantly increased average daily gain ($P<.05$) and efficiency of feed conversion ($P<.05$) over the basal. The antibiotic-fed wethers consumed 13% more feed than the basal lots. There was a significant correlation (r +0.81) between gain and feed intake. Average dry matter digestion coefficients for the self-fed basal, self-fed antibiotic, limited-fed basal and limited-fed antibiotic lots, were 63.0, 65.4, 65.6 and 70.3, respectively. Hygromycin A significantly improved ($P<.01$) the digestibility of the basal ration. A comparison of methods of feeding revealed a significant effect ($P<.01$) in favor of the limited-fed lots.

49. CHLORTETRACYCLINE IN PELLETED AND UNPELLETED, UREA AND COTTONSEED MEAL CONTAINING RATIONS FOR FATTENING LAMBS WITH A REFERENCE TO URINARY CALCULI. Leonard V. Packett, T. D. Watkins, Jr. and H. O. Kunkel, *Texas Agricultural Experiment Station.*

Previous work has indicated chlortetracycline (Aureomycin) to be of value in reducing the incidence of enterotoxemia and digestive disorders coincident with placing lambs on a self-fed ration for fattening purposes. A 98-day feeding trial involving 280 feeder lambs divided into 7 lots was conducted to determine the effect of chlortetracycline in pelleted and unpelleted rations with urea or cottonseed meal (CSM) as a source of nitrogen. The CSM ration was composed of 45% ground milo, 10% CSM, 10% molasses, 8% ground alfalfa, 27% ground cottonseed hulls. The TDN and crude protein were the same in rations fed lots I-VI. The protein supplement was omitted in the ration fed Lot VII. The treatments and average daily gains in pounds were: Lot I, pelleted, urea, 0.36; Lot II, pelleted, urea, plus chlortetracycline, 0.39; Lot III, pelleted, CSM, 0.38; Lot IV, pelleted, CSM, plus chlortetracycline, 0.40; Lot V, unpelleted, CSM, 0.37; Lot VI, unpelleted, CSM plus chlortetracycline, 0.40; Lot VII, pelleted, as Lot I except urea left out, 0.33. In the pelleted ration, chlortetracycline did not appear to inhibit the utilization of urea. Urinary calculi was significantly reduced by the inclusion of chlortetracycline in the ration ($P<.01$). Death losses due to urinary calculi were significantly greater in lambs fed the CSM ration as compared to those fed the urea ration ($P<.01$). Data on gross and histological observations of the kidneys, mineral and vitamin A content of the blood and vitamin A content of the liver will be presented.

50. CHOPPED VERSUS PELLETED ALFALFA WITH AND WITHOUT ADDED BARLEY OR CHLORTETRACYCLINE (AUREOMYCIN) FOR FATTENING LAMBS. W. C. Weir, N. R. Ittner and J. H. Meyer, *University of California.*

A lamb feeding trial and a digestion trial were used to study dehydrated alfalfa in chopped and pelleted form. All alfalfa was taken from the same field at the same time. Rations were I—Chopped alfalfa, II—Pelleted alfalfa, III—Pelleted alfalfa with 10 mg. chlortetracycline per lb., IV—Chopped alfalfa plus 30% ground barley, V—Pelleted alfalfa with 30% ground barley, and VI—Pelleted alfalfa with 30% ground barley and 10 mg. chlortetracycline per lb. Average daily gains were I—0.30, II—0.39, III—0.41, IV—0.31, V—0.36, and VI—0.37 lb. Gains were higher ($P<0.01$) on pelleted rations. The addition of barley or chlortetracycline did not significantly increase gains. Average daily feed consumption was I—3.1, II—3.7, III—4.0, IV—2.8, V—3.2 and VI—3.3 lb. Feed per 100 lb. gain was I—1031, II—943, III—969, IV—916, V—897, VI—890. Dressing percentages and carcass grades were higher for the lambs fed the pelleted rations. Digestion trial results showed no difference in total digestible nutrients except due to the addition of barley. Apparent digestibility of protein was unchanged except that lot VI had a slightly increased digestibility. Fiber digestion coefficients were I—51, II—47, III—48, IV—53, V—42, and VI—44.

51. EFFECT OF RATION ON CONTROL OF UNDESIRABLE MICROORGANISMS IN THE RUMEN OF SHEEP. G. B. Garner, W. H. Pfander and M. E. Muhrer, *University of Missouri.*

The effect of rations and silage extracts on the ability of the rumen to control undesirable organisms was studied. The digestibility of nitrogen and cellulose was determined to study the effects of the organism, *P. aeruginosa.* Twelve fistulated wethers were divided equally between Ration I, composed of 800 gm. alfalfa hay, 350 gm. corn and 50 gm. of a protein supplement containing minerals and vitamins and Ration II, composed of 800 gm. timothy hay and 212 gm. of the same protein supplement. Three sheep in each lot received a silage extract equivalent to 0.6% of fresh

silage per day. Five ml. of a 24-hour culture of *P. aeruginosa* was given daily on the ration until a count of 10^6 organisms per ml. of rumen fluid was obtained 24-hours after inoculation. Mean coefficients of digestibility for cellulose before and after inoculation were: 60.37, 59.44 for Ration I and 56.29, 46.47 for Ration II. Mean coefficients of digestibility for nitrogen were: 65.76, 63.08 for Ration I and 39.81, 46.50 for Ration II. Bacterial counts of *P. aeruginosa* during the inoculation period indicated a greater resistance to the establishment of *P. aeruginosa* in the rumen of the alfalfa fed sheep. Silage extract was not effective. Final control of *P. aeruginosa* was by polymyxin B sulfate.

52. PRODUCTION AND STUDY OF VITAMIN E DEFICIENCY IN THE BABY PIG. R. M. Forbes and H. H. Draper, *University of Illinois.*

Two eight week feeding experiments were conducted with a total of 38 pigs. In both experiments the basal E-low diet was made from casein plus methionine 20%, cerelose 45%, vitamin E-free lard 29%, minerals and vitamins. In experiment I the basal, basal plus vitamin E, and basal plus 2% cod liver oil made up groups 1, 2 and 3. Criteria were: weight gain, blood plasma vitamin E, ratio of preformed to total urinary creatinine, histological study of skeletal and cardiac muscle. In experiment II the same basal diet was used, but cod liver oil was substituted for a portion of the lard to provide diets with 5 or 10% CLO. Each of these two diets was fed without and with vitamin E. Criteria used were weight gain, ratio of performed to total urinary creatinine, electrocardiograms, and histological study of skeletal and cardiac muscle. The results of experiment I were inconclusive although there was slight evidence of skeletal muscle degeneration and smaller weight gains in group 3. No plasma vitamin E was detectable in blood of either groups 2 or 3 at end of experiment, and there was no effect of treatment on preformed/total urinary creatinine ratio. The results of experiment II were clear-cut, presence or absence of vitamin E clearly affecting weight gain, preformed/total creatinine ratio and histological evidence of skeletal and cardiac muscle degeneration. Electrocardiograms were not affected by the imposed treatments.

53. THE ROLE OF VITAMIN E AND SELENIUM IN THE NUTRITION OF THE PIG. R. G. Eggert, E. Patterson, W. T. Akers and E. L. R. Stokstad, *American Cyanamid Company, Pearl River, New York.*

Six littermate trios of 2 to 3 week-old pigs were individually fed purified-type diets containing Torula yeast, 40%; glucose (cerelose), 40%; cellophane, 3%; vitamin E-free lard, 5%; calcium gluconate, 5%; ground limestone, 2%; methionine, 0.4%; cystine, 0.27%; and salt, 0.5%. These were supplemented with minerals and all the known vitamins except vitamin E. One member of each trio received the basal diet; another member received the basal diet supplemented with 40 ppm tocopheryl acetate, while the third member received the basal diet supplemented with 1 ppm of selenium added as sodium selenite. Four of the six pigs receiving the basal diet died within 53 days after the start of the test. Deaths occurred suddenly without previous outward manifestation of ill health. Each pig that died showed a marked necrosis of the liver. Two of the four pigs also exhibited a yellowish-brown discoloration of the body fat, and showed hemorrhages in the lymph nodes and gastrointestinal tract. No deaths occurred among the pigs receiving vitamin E or selenium. Average daily gains and feed efficiencies were good for all animals. No marked differences in growth rate was noted for any of the treatments up to the time of the death of pigs receiving the basal diet. Three pigs each receiving vitamin E and selenium were sacrificed after 57 to 66 days on test. No gross evidence of liver necrosis or discoloration of body fat was found in any of these animals. Tissue samples were obtained from all pigs that died or were sacrificed and results of the histopathology studies will be presented.

54. ORAL AND PARENTERAL ADMINISTRATION OF IRON IN THE PREVENTION AND TREATMENT OF BABY PIG ANEMIA. D. E. Ullrey, E. R. Miller, D. R. West, D. A. Schmidt, R. W. Seerley, J. A. Hoefer and R. W. Luecke, *Michigan State University*.

One hundred and seventy-five baby pigs were used to compare the efficacy of oral vs. parenteral iron in the prophylaxis and therapeusis of anemia. Experimental treatments included lots receiving iron-copper-cobalt tablets orally, iron-dextran intramuscularly, iron-dextran intramuscularly plus an intraperitoneal injection of hemopoietic B-vitamins, and non-treated lot. Complete hematology was performed weekly on forty of the animals while hemoglobin and hematocrit determinations were made biweekly on the remainder. Pigs receiving the iron-dextran injection had significantly higher blood hemoglobin, hematocrit, reticulocyte response, erythrocyte population and mean corpuscular volume than the pigs receiving the oral treatment. These advantages for parenteral iron over oral iron were apparent by the third week of age and persisted through the fifth week but there was no significant weight advantage at five weeks for the pigs receiving parenteral iron. Recovery from acute anemia was much more rapid in pigs receiving injected iron-dextran than in those which received oral iron. Hemoglobin and hematocrit values returned to near normal within one week in acutely anemic pigs which received the iron-dextran injection. Twenty-seven baby pigs raised concurrently on a synthetic milk diet containing 228 ppm of elemental ferrous iron had considerably higher hemoglobin and hematocrit values throughout the five week period than any of the treatment groups raised on the sow.

55. GROWTH AND CHEMICAL STUDIES OF ZINC DEFICIENCY IN THE BABY PIG. D. W. Beardsley and R. M. Forbes, *University of Illinois*.

A low zinc, semi-purified basal ration containing 22% crude protein, 0.62% calcium, 0.74% phosphorus and 9 ppm zinc was developed to study growth, deficiency symptoms, tissue and total carcass zinc concentration and a seven day zinc balance in the young pig. Three lots of seven two-week-old pigs were given these treatments: lot I, basal; lot II, basal plus 0.8% calcium; lot III, basal plus 90 ppm zinc. At the end of a six-week test period, three pigs from each lot were slaughtered for samples. Two pigs each from lots I and II were maintained on their respective rations for two more weeks while the remaining two pigs in these lots were given supplemental zinc to check recovery. By the end of the second week on test, both lots on the low zinc rations showed reduced feed consumption. During the third and fourth weeks, reddish, scabby patches began to appear on the skin of all pigs on the low zinc rations. Response to added zinc in the recovery phase was almost immediate and after two weeks of zinc supplementation the pigs had about doubled in size and most of the scabs on the skin had sloughed. Average daily gains (lb.) for the six-week feeding period were: lot I, 0.21; lot II, 0.23, lot III, 0.67. During recovery gains were lot IA, 0.93, and lot IIA, 0.89. Added calcium did not influence the severity of parakeratosis. Tissue and carcass zinc concentration and zinc balance data will be presented.

56. THE MAGNESIUM REQUIREMENT OF SWINE WEANED AT THREE AND NINE WEEKS OF AGE. R. H. Mayo, M. P. Plumlee and W. M. Beeson, *Purdue University*.

A total of 96 pigs, 6 per treatment, were used in a study of the Mg requirement of swine fed semi-purified rations. Levels of 1 and 340 ppm Mg were compared in experiment I which consisted of three phases: depletion, repletion and depletion. Magnesium was required by the 3 week old pigs to maintain optimum growth, feed utilization, serum Mg and to prevent a Mg deficiency. Deficiency symptoms in order of appearance from the 14th to the 20th day were: hyperirritability, muscular twitching, reluctance to stand, weak pasterns, loss of equilibrium and tetany followed by

death (50% mortality resulted on the low Mg diets). In experiment II the feeding of diets containing 1, 68, 136, 204, 272 and 340 ppm of Mg for 42 days produced daily gains of 0.93, 1.03, 1.48, 1.64 and 1.74 lb., respectively, for survivors (mortality was 83.5, 33.3 and 16.7% for lots 1, 2 and 3, respectively). The gains of the 272 and 340 ppm of Mg groups were higher ($p<0.05$) than any lower level. In experiment 3, 8-week old pigs were fed 42 days on diets containing 1, 90, 180, 270, 360 and 450 ppm of Mg. Daily gains were 0.99, 1.34, 1.71, 1.72 and 1.74 lb., respectively. The 1 and 90 ppm of Mg groups gained slower ($p<0.01$) than those on the higher levels. Although marked deficiency symptoms appeared the second week, no deaths occurred. In all trials feed efficiency closely paralleled growth rate and serum Mg increased almost linearly with the dietary Mg level. These data indicate that the pig requires at least 270 ppm of Mg in the diet for optimum growth and feed utilization.

57. DIFFERENCES IN ANTIBODY PRODUCTION BETWEEN NURSING PIGS AND THOSE FED SYNTHETIC MILK DIETS. E. R. Miller, D. A. Schmidt, D. E. Ullrey, J. A. Hoefer and R. W. Luecke, *Michigan State University.*

Initially, a trial was conducted to determine the effect of riboflavin, pyridoxine and pantothenic acid deficiencies upon the antibody producing ability of the baby pig. Antibody producing ability was measured by the tube serial dilution agglutination test. The antigen used was a 20% suspension of human erythrocytes in saline. Poor antibody production was observed in the B-vitamin deficient pigs and also in pigs receiving a complete synthetic milk diet. All pigs had been allowed to nurse the sow for four days before being placed on the synthetic diet. Pigs which remained on the sow showed a much greater antibody response to the injected antigen. Pigs which had been raised on the complete synthetic milk to weaning age and then placed on a practical starter diet exhibited an excellent antigen-antibody response. Subsequently, another trial was conducted to determine the comparative antigen-antibody response of baby pigs raised on the complete synthetic milk diet, pigs raised on a commercial sow milk replacer and pigs on the sow. Again all pigs nursed the sows for four days before being lotted. Pigs which continued nursing the sow were superior in antibody production to both of the other lots. This test was made during the third and fourth weeks of age. Total serum protein values were similar in pigs of three lots. However, serum gamma globulin was less and serum albumin greater in pigs nursing the sow than in the pigs raised on the milk substitutes. Forty-eight baby pigs were used in these trials.

58. THE ROLE OF THE CAECUM IN NUTRIENT UTILIZATION BY THE PIG. L. E. Lloyd, D. G. Dale and E. W. Crampton, *Macdonald College (McGill University), Canada.*

In an effort to determine the extent to which various ration nutrients are digested in the caecum, a total of five pigs from two litters were caecectomized at approximately six weeks of age. Laboratory prepared rations containing varying levels of protein, fiber and fat, as well as commercial starter, grower and finisher rations were fed to caecectomized and physically normal littermates. Caecectomy had no deleterious effects on the growth of the pig. Differences in ability to digest dry matter, gross energy, crude protein, crude fiber, ether extract and nitrogen-free extract, while in most cases in favor of the normal animals, were of small magnitude. Thus it appeared that the caecum plays a relatively insignificant role in nutrient utilization by the pig.

59. FACTORS AFFECTING THE NUTRITIVE VALUE OF DRIED WHEY AND ITS UTILIZATION IN SWINE DIETS. L. J. Hanson, D. E. Becker, A. H. Jensen and S. W. Terrill, *University of Illinois.*

Ninety pigs were used in two studies to test the effect of feeding lactase with high levels of dried whey. With a diet containing 35 and 70% dried whey the addition of 0.5% lactase concentrate gave no significant improvement in growth rate or feed

efficiency in the weanling pig. In addition, suckling, weanling or finishing pigs fed 35% dried whey failed to exhibit a beneficial response to lactase. A determination of the lactase activity of the duodenal area of the gut indicated an exogenous source of lactase increased the activity. The lactase activity varied indirectly with age but it was not influenced by dietary lactase. Three experiments involving 180 two-week old pigs were conducted from 4–6 weeks to determine the value of dried whey at 25 and 50% of the diet. In the first experiment 50% soybean oil meal or soybean oil meal and dried skim milk was fed in the presence or absence of dicalcium phosphate. Dried skim milk improved the gain at the high level of dried whey whereas the addition of dicalcium phosphate was without effect. In the second experiment 50% soybean oil meal with and without NaCl, meat and bone scraps, blood flour with and without dried skim milk and casein were tested as supplementary sources of protein at each level of dried whey. Soybean oil meal and meat and bone scraps promoted the most rapid and efficient gains. In the third experiment soybean oil meal was superior to meat and bone scraps and the presence of NaCl appeared to depress the rate and efficiency of gain.

60. ENZYME SUPPLEMENTATION OF BABY PIG RATIONS CONTAINING VARIOUS CARBOHYDRATE AND PROTEINACEOUS FEEDSTUFFS. W. L. Alsmeyer, G. E. Combs, Jr. and H. D. Wallace, *University of Florida.*

Four experiments were conducted with 260 pigs weaned at 9–11 days. Experiment 1 used dried skim milk (DSM) with sugar; corn; sugar-corn combination (SCC); SCC plus 1% animal diastase (1:125) and the latter plus 0.5% Ethomid C/15. Experiment 2 used poultry by-products meal and soybean oil meal (SBOM) in conjunction with sugar; sugar plus 1% pepsin (1:3000) plus 1% pancreatin (N.F.); SCC; and SCC plus pepsin and pancreatin with and without 0.1% Ethomid C/15. Treatment differences were not significant in either of these experiments after 28 days. Experiment 3 used a feather meal (FM), SBOM and sugar ration supplemented with pepsin, pancreatin, sucrase and various combinations of these enzymes. After 3 weeks, feed efficiency but not daily gain was significantly improved by enzyme supplementation. Removal of enzymes from rations fed to one replication of Experiment 3 did not significantly affect 7 week performance when compared to the enzyme-continued replication. Experiment 4 (7 wk.) used rations of DSM and SCC (basal); plus 0.5% animal diastase (1:25); and the latter plus 0.25% pepsin; FM, SBOM and SCC (basal); plus diastase; and diastase plus pepsin. These rations were compared to a FM, SBOM, sugar and pepsin ration supplemented with normal or triple vitamin levels. The latter ration was fed for a 1 or 3 week period, then substituted for a "creep-type" ration. Daily gains and feed efficiencies for Experiment 4 were: 0.76, 0.80, 0.82, 0.60, 0.56, 0.63, 0.54, 0.56, 0.32, 0.36 and 2.06, 1.94, 2.09, 2.14, 2.15, 2.17, 1.90, 1.98, 2.78 and 2.78 lb., respectively.

61. EFFECT OF SACCHARIN AND SUGAR ON PIG STARTER PERFORMANCE. S. M. Aldinger, P. G. Homeyer, V. C. Speer, V. W. Hays and D. V. Catron, *Iowa State College.*

Five experiments, involving 546 pigs, were conducted to determine the baby pigs preference for saccharin (Gluside-soluble and Gluside-insoluble), and the effect of feeding saccharin and/or sugar on average daily gain and feed efficiency. In determining the baby pigs preference for saccharin, two different methods were evaluated. The first method used was to compare five different levels of saccharin (0, ⅛, ¼, ½, 1 lb./ton) in separate feeders within the same pen. This method was later modified to include only two feeders per pen with the six possible combinations of four levels of saccharin (0, ¼, ½, 1 lb./ton) as the treatments. In all three experiments there was a definite preference for saccharin, although there was considerable variation between levels. However, the use of only two feeders per pen reduced this variation and the

percentage of any one level consumed remained quite constant throughout the four week feeding period. The results of the direct comparison tests in which different combinations of saccharin (0, ¼, ½, 1 lb./ton) and sugar (0, 5, 10, 15%) were fed showed that optimum gains were obtained with one lb. of saccharin per ton of starter.

62. LEVELS OF ALFALFA IN SWINE REPRODUCTION RATIONS. Stuart Tilton, Alva E. Flower and O. O. Thomas, *Montana Agricultural Experiment Station.*

The results of feeding forty-five sows three levels of sun-cured alfalfa in a gestation ration are described. Alfalfa levels were 20, 50, and 100%. The 20 and 50% levels were ground and mixed with concentrate, while the 100% level was fed long from a rack. The 20% level was hand-fed, while the 50% level was self-fed. The sows and pigs from the three lots were handled and fed similarly from the time they were put in the farrowing houses. When all females in a treatment were considered together, 89% on the 20% alfalfa ration farrowed and weaned litters. They consumed 8.41 lb. of feed per sow per day during gestation. On the 50% alfalfa level, 77.7% farrowed, and the same number weaned litters. They consumed 9.92 lb. of feed per sow per day during gestation. On the 100% alfalfa level, 61.1% farrowed, but only 55.5% weaned litters. The sows receiving 100% alfalfa consumed only 3.76 lb. of feed per sow per day during gestation. When considering gilts and sows separately, gilts produced heaviest pigs at birth on 20% alfalfa while 50% alfalfa was best for sows. Both sows and gilts produced more live pigs at birth on the 20% level of alfalfa, but gilts on the 50% weaned more pigs and heavier litter weaning weights than other levels. Sows on 50 and 100% levels of alfalfa did not differ significantly in live pigs born.

63. THYROPROTEIN FOR LACTATING SOWS. C. W. Johnson, V. C. Speer, V. W. Hays and D. V. Catron, *Iowa State College.*

Six experiments were conducted including 224 sows and litters to determine the effect of thyroprotein supplementation on lactation performance. The ration used was moderately high in energy and highly fortified with B vitamins and trace minerals. In experiment 1 the 50 mg. level did not improve pig gain while the 100 mg. level improved pig gain and had little if any effect on respiration rate or rectal temperature. The 200 mg. level increased the metabolism of the sow and did not improve pig gains. In experiments 2 and 3 the pigs nursing the thyroprotein supplemented sows gained 27% more during the first week and pig mortality was 0.3 pig less per litter. All the sows were full-fed from farrowing and there was no difference in feed consumption due to ration treatment. Experiment 4 (field test) involved 58 litters weaned at 2 weeks. The pigs nursing the thyroprotein and the control sows gained 5.4 and 4.8 lb. respectively while the mortality per litter was .9 and 1.4 pigs respectively. Experiment 5 (field test) involved 58 litters weaned at 3 weeks. The pigs nursing the thyroprotein and the control sows gained 9.7 and 9.1 lb. respectively while the mortality per litter was .6 and 1.0 pigs respectively. Experiment 6 involved 16 sows and litters weaned at 5 weeks of age without pig starter rations. The pigs nursing the sows supplemented with thyroprotein for 5 weeks gained, 17.4 lb.; thyroprotein supplementation started at 1 week of age, 17.0 lb.; control sows, 15.6 lb.; thyroprotein supplementation withdrawn at 1 week of age, 14.3 lb. The nursing sow weight loss for the thyroprotein supplemented and control sows was 28.0 and 18.3 lb. respectively, while the weaning sow weight loss was 36.5 and 47.3 lb. respectively. There was no difference in total sow weight loss due to ration treatment from 3 days post partum to 4 days post weaning. There was no difference in sow feed consumption due to ration treatment.

64. THE INFLUENCE OF A THYRO-ACTIVE COMPOUND IN DIETS FOR SWINE DURING LACTATION. W. A. Dudley, D. E. Becker, A. H. Jensen and S. W. Terrill, *University of Illinois.*

Four experiments employing 109 sows and gilts were conducted to determine the influence of iodinated casein when included in practical sow diets at a level of 100 mg. per lb. The first two experiments were initiated five days before farrowing and continued until weaning at six weeks of age. During the last 4–5 weeks the sows were maintained on rye pasture. For the entire period there resulted an average weight loss of 12 lb. for the control group and 56 lb. for the sows receiving iodinated casein in the first experiment (Hybrids), and 29 lb. and 76 lb. respectively in the second experiment (Durocs). At the termination of the second experiment the sows were placed in dry lot for 48 hours without access to feed. The sows receiving iodinated casein shrank an average of 24 lb. as compared to 33 lb. for the controls indicating that the difference in weight loss is not solely a difference in fill. The next two experiments were initiated when the litters were 2 weeks of age and continued until weaning at six weeks. The first experiment was conducted in dry lot and the second on alfalfa pasture. The sows receiving iodinated casein lost an average of 19 lb. and the controls gained an average of 12 lb. in the first experiment (Crossbreds) while in the second experiment (Yorkshires) no substantial differences were noted in regard to sow weight loss. No significant differences were noted in regard to pig weight and performance in the above experiment. The effect of added vitamins and energy was tested.

65. THE EFFECT OF SELENIUM AND ARSANILIC ACID ON GROWTH, REPRODUCTION AND LACTATION PERFORMANCE OF SWINE. Richard C. Wahlstrom and Oscar E. Olson, *South Dakota State College.*

Thirty weanling Duroc pigs, all females, were used to study the effect of selenium and arsanilic acid on growth, reproduction and lactation performance. The pigs were self-fed *ad libitum* practical diets consisting of yellow corn, oats, alfalfa, soybean oil meal, tankage, minerals and vitamins. The proportions of each ingredient were varied as the experiment progressed. Ten gilts were allotted to each of the three treatments which were: Group I—Basal, Group II—Basal plus 10 ppm of selenium (Se) and Group III—Basal plus 10 ppm of Se and 0.01% of arsanilic acid (AA). AA prevented visible selenium toxicity symptoms and the growth rate was comparable to the control ration. The number of services required per conception was increased, and the conception rate decreased when either Se or Se plus AA were fed. Average number of pigs farrowed, percentage farrowed alive and birth weights were as follows: Group I, 8.0, 100, 2.95; Group II, 9.8, 78, 2.60 and Group III, 7.5, 88, 2.55. Data on the lactation performance will also be presented.

66. THE EFFECT OF ENERGY INTAKE AND GROWTH ON THE SPERMATOGENIC CAPACITY OF YOUNG BULLS. N. L. VanDemark and R. E. Mauger, *University of Illinois.*

The effects of 60 and 100% TDN intake (based on mid-point of Morrison's standards) and growth on the spermatogenic capacity of young bulls has been studied by the partial exhaustion technique (10 ejaculates in 90 min.). Partial exhaustions following the initial were repeated at 1, 4, 7 and 13-day intervals when the bulls were 384, 492 and 614 days of age. The average body weight and daily rate of gain for the 60 and 100% intake bulls to 614 days of age were 564 lb. at 0.71 lb. per day and 1131 lb. at 1.62 lb. per day, respectively. The average body weights and measurements of height at withers and circumference of chest were compared to the Ragsdale standards. The data indicated that the 60% intake bulls lacked both skeletal size and flesh but the 100% intake bulls were normal in skeletal size but slightly underweight. Limited energy intake significantly affected the numbers of total sperm ejaculated at

the three age periods. The intervals necessary to replenish the total number of sperm ejaculated at the initial partial exhaustion by the 100% intake bulls were 12, 10 and 7 days at the three respective trials. The rate of replenishment of the total number of sperm ejaculated by the 60% intake bulls at the initial partial exhaustion of the first two trials was highly variable; however, replenishment was completed by 12 days at the third trial. The rate of replenishment increased as body weight and age increased.

67. EFFECTS OF EXTERNAL IRRADIATION OF PREGNANT FEMALE RATS ON VIABILITY, GROWTH AND FERTILITY OF THE OFFSPRING. H. B. Pace and R. L. Murphree, *University of Tennessee.*

Pregnant female rats were used in a study of the effects of irradiation (Co-60) on the viability, growth and fertility of the offspring. Nineteen females were not exposed (controls) 25 received 110 r and 21 received 220 r. The stage of pregnancy varied from 10–19 days at the time of irradiation and all females littered. The average litter size at birth was 9.8, 11.1 and 11.3, respectively. The average percent of young alive at 24 hours were 95.9, 80.2** and 19.5** and at 21 days of age were 86.7, 50.0** and 15.2**, respectively for the three groups. Only 4 of 21 litters in the 200 r group survived longer than 24 hours after birth. The average weaning weights of the offspring in the 3 groups were 36.7, 30.4* and 26.3** gm., respectively. Lowered fertility was observed in the irradiated offspring. Twenty-eight pregnant rats were paired on the basis of breeding dates and one female of each pair was irradiated (150 r) on the 17th day of gestation. On the 5th day of age, all litters were standardized to 10 young and equal numbers exchanged between control (C) and irradiated (I) dams. The average weights of the control (CO) and irradiated (IO) offspring, at exchange, were 9.9 and 8.4 gm., respectively. The average weaning weights of the CO on C dams, CO on I dams, IO on C dams and IO on I dams were 42.9, 41.1, 33.8, and 32.9 gm., respectively. The difference in growth between the young suckling control vs. irradiated dams was significant ($P<.05$). The difference in growth between the control and irradiated offspring was highly significant ($P<.001$).

68. TIME OF PLACENTAL ATTACHMENT IN THE BOVINE. G. B. Marion, H. T. Gier and J. T. Haldiman, *Kansas State College.*

Gravid uteri from 28 dairy cows with known reproductive histories were used to study placentation. At 27 days gestation there is no placental attachment. The allantois has begun to fuse with the serosa in the region of the embryo. Caruncles are stretched but not noticeably stimulated. Between 31 and 34 days chorioallantois nearly fills the pregnant horn, and caruncles in contact with the first formed chorioallantois are ridged across their surface by enlarging loops of uterine capillaries pressing against the epithelium. Also, the chorioallantois thickens, matching the furrows of the caruncles. Ridges form across the furrows as more uterine capillaries expand, leaving crypts between crossed ridges, with each crypt containing a chorionic villus. These capillary-filled ridges (caruncular septa) press farther into the uterine cavity, and villi match the expansion with original villus tips remaining against the original caruncular epithelium. As the mass expands into the uterine cavity, it expands parallel to the uterine wall with secondary septa forming within walls of crypts, thus inducing "branching" of villi. Interlocked septa and villi produce a firm placentome by 38 days gestation. Additional caruncles are stimulated to ridge formation progressively farther from the embryo, lagging four to six days behind chorioallantoic formation, closely following allantoic blood vessels in serosal mesoderm. By 34 days, caruncles which were adjacent to the allantois have been visibly stimulated, and by 38 days the stimulation has progressed into the non-pregnant horn. Placentomes continue to develop in the non-pregnant horn until about 90 days gestation.

69. THE RELATIVE BACTERICIDAL ACTIVITY OF UTERINE EXUDATE OF ESTROUS AND PSEUDOPREGNANT RABBITS. H. W. Hawk and J. F. Sykes, *AHRD, Dairy Cattle Research Branch, USDA, Beltsville, Md.*

The uteri of follicular-phase cows and rabbits possess greater bactericidal activity than do the uteri of luteal-phase animals. One uterine horn of 7 pseudopregnant rabbits was ligated at each end, inoculated with *Escherichia coli* and injected with uterine exudate from estrous rabbits to determine the effect of the exudate on bacterial recovery. The exudate was obtained by flushing 4-hour inoculated uteri of estrous rabbits with 1 ml. of saline and removing leukocytes by centrifugation. The mean log number of *E. coli* recovered from the exudate-infused horns after 4 hours was 7.31 and from inoculated control horns in other pseudopregnant rabbits, 8.64 ($P<0.05$). The exudate may have stimulated the uterine defense mechanism of the recipient rabbits, as indicated by increased leukocytic response; uterine exudate from 14 estrous and 8 pseudopregnant rabbits was therefore tested *in vitro* for bactericidal activity. The uterine flushing from these rabbits, inoculated 4 hours previously, were centrifuged at 14,000 G for 30 minutes to remove differential numbers of bacteria, inoculated with known numbers of *E. coli* and incubated along with inoculated saline for 2 hours at 37° C. The mean log numbers of live *E. coli* recovered from exudate or saline were: estrous, 6.71; pseudopregnant, 7.91; saline, 8.21. The differences between estrous rabbit exudate and saline and between estrous and pseudopregnant rabbit exudates were significant ($P<0.01$), suggesting the presence of bactericidal factors in the estrous rabbit exudate and a difference between estrous and pseudopregnant rabbit exudates in bactericidal activity.

70. EFFECTS OF RESERPINE ON LACTATION. Joseph Meites, *Michigan State University.*

The drug reserpine has been observed to influence the function of several endocrine glands. Recently we have been able to confirm the brief report of Sawyer (Anat. Rec. 127:362, 1957) that reserpine can initiate lactation in rabbits. Eight mature virgin rabbits were injected subcutaneously for 2 successive days with 0.2 mg. estradiol daily, and on the third day 4 were injected intravenously with 1 mg. reserpine per kilo body weight. The other 4 served as controls. One week later milk could be expressed from the nipples of 3 of the reserpine-treated rabbits and from none of the controls. Four additional rabbits were made pseudopregnant by intravenous administration of chorionic gonadotrophin, and 15 days later 2 of these rabbits were injected once intravenously with 1 mg. reserpine per kilo body weight. Only the 2 reserpine-treated rabbits came into lactation. In no instance was the lactation response induced by reserpine equal to that seen after parturition. Reserpine is currently being injected into milking goats to determine its effects on established lactation. The mechanisms by which reserpine initiates milk secretion in rabbits is unknown, but it may stimulate secretion and/or release of prolactin from the anterior pituitary.

71. A STUDY OF PITUITARY RELEASE OF LACTOGENIC HORMONE. Clark E. Grosvenor* and Charles W. Turner, *University of Missouri.*

Pituitary glands from lactating rats were assayed for lactogenic hormone using a refinement of the Reece-Turner pigeon method. All rats were isolated from their litters of 6 young for 10 hours on the 14th day. Fifteen pituitaries assayed at the end of this period had an average of 2.44 Reece-Turner (R-T) units/100 gm. All remaining animals were reunited with their litters and permitted to nurse for 30 minutes. Fifteen each were killed 15 minutes, 2.5 hours and 9.5 hours after nursing. Results showed

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pituitary lactogen dropped to 1.70 R-T units/100 gm. immediately after nursing and gradually restored to the pre-nursing level in those killed 2.5 hours (2.14 R-T units/100 gm.) and 9.5 hours (2.22 R-T units/100 gm.) after nursing. To determine neural factors involved in release of lactogenic hormone, 45 lactating rats were killed 15 minutes after nursing of which 20 were injected subcutaneously 2 hours before nursing with 60–80 mg./Kg. Dibenamine-Cl and 25 injected subcutaneously with 700 mg./Kg. atropine-SO_4 20–120 minutes prior to nursing. Results indicate both drugs block pituitary release of lactogenic hormone since nursing evoked no decline from pre-nursing lactogen levels. These results indicate the rapidity in which lactogen is released in the rat in response to nursing stimuli and suggest adrenergic and cholinergic components are involved in the release mechanism.

72. EFFECTS OF SUCKLING, PITOCIN AND CERVICAL STIMULATION ON RELEASE OF PROLACTIN IN THE PARTURIENT RAT. Robert M. Johnson and Joseph Meites, *Michigan State University*.

Twenty mature female rats were bred and at parturition were divided into 4 groups of 5 each. On the 3rd postpartum day, their litters were removed and they were treated as follows: (1) The dams were killed at the end of 15 hours after separation from their young. (2) The young were removed for 12 hours, then permitted to suckle for 3 hours at the end of which time the dams were killed. (3) After 12 hours separation from their young, these rats were injected subcutaneously with 1.0 I.U. pitocin on the 12th, 13th, 14th and 15th hours, and were then killed. (4) After 12 hours of separation from their young, the cervices of these dams were electrically stimulated for one minute periods on the 12th, 13th, 14th, and 15th hours and the dams were then killed. In all four groups the pituitaries were removed and assayed for prolactin. Suckling decreased the pituitary prolactin content in lactating rats below that of non-suckled rats. Electrical stimulation of the cervix and injections of pitocin produced an increase in pituitary prolactin content as compared to non-suckled rats. Twenty-three other pregnant rats were divided into 3 groups, and on the day of parturition their litters were reduced to 6 each. The dams received daily subcutaneous injection for 28 days as follows: (1) Controls, saline only; (2) 1.0 mg. prolactin; (3) 1 I.U. oxytocin. The litters were weighed daily for 18 days at the end of which time the young were removed and the injections continued in the dams for an additional 10 days. On the 28th day the dams were killed and the right inguinal mammary gland was removed for histological examination. Oxytocin and prolactin produced an increase in the growth rate of the young over the controls. Prolactin markedly retarded while oxytocin had no effect on mammary involution. It is concluded that oxytocin does not release prolactin from the pituitary, and that its favorable action on lactation differs from that of prolactin.

73. ABSENCE OF ANDROGENIC CHROMOGENS IN THE URINE OF RUMINANTS. A. M. Gawienowski, W. S. Ruliffson, M. J. Twiehaus and J. S. Hughes, *Kansas State College*.

The ruminant urine was tested qualitatively for chromogens using the Pincus, Allen and Zimmerman reactions. The absorption spectra of the chromogens of the cow, goat and lamb urine, and of androsterone and dehydroepiandrosterone, were recorded and compared for similarities. The absorption spectra obtained with the urine extracts differed from spectra obtained from the 17-ketosteroids. The absorption spectra of the three color reactions with ruminant urines were similar to that reported by Mixner *et al.* (J. Dairy Sci. 40:1, 1957) for 5-hydroxy-cis-tetrahydro-ionone. However, it was found that the chromogens in the ruminant urine would mask the absorption spectra of low concentrations of the 17-ketosteroids when the ketosteroids and urine were mixed together. The urine of stilbestrol-treated wethers was studied for androgen secretion by the Zimmerman, Pincus and Allen reactions. By these methods, it was

observed that the urine of the wethers did not have characteristic absorption maxima of the 17-ketosteroids. Moreover, the urine extract of eight wethers was found to be negative for androgens when tested by the chick comb test. This preliminary work suggests that there is little, if any, 17-ketosteroids in cow, doe, ewe and wether urine.

74. SARCOSINE AND CREATINE AS NITROGEN SOURCES FOR THE RUMINANT. C. D. Campbell, G. A. McLaren, G. S. Smith, G. C. Anderson, J. A. Welch and J. Brooks, *West Virginia University*.

Creatine and sarcosine, alone and in combination with urea and vitamin B_{12}, were evaluated as nitrogen sources. Four digestion and nitrogen metabolism experiments were conducted with wether lambs using semi-purified rations containing 4.5 ppm. of cobalt and 1.8% nitrogen with wheat straw as the source of fiber. Creatine, sarcosine, urea or combinations of these compounds furnished 67% of the total ration nitrogen. All lambs fed vitamin B_{12} received 10 mcg. daily. In experiments I and II creatine was fed, with and without vitamin B_{12}, at levels of 0, 2.5, 7.5, 15, 33, 67 and 100% of the ration NPN with urea supplying the remainder. The 7.5 and 15% creatine levels significantly ($P<.05$) improved the digestibility of organic matter and NFE while at the 33% level the improvement in digestibility of organic matter, crude fiber and NFE was highly significant ($P<.01$). Creatine had no effect upon N utilization. Two successive 10-day collection periods were used in experiments III and IV to compare 33% creatine and 33% each NPN source was fed with and without vitamin B_{12} and four lambs were included in each treatment. Neither creatine, sarcosine nor vitamin B_{12} influenced N utilization. Vitamin B_{12} significantly ($P<.05$) improved the digestibility of organic matter and the improvement in protein digestibility was highly significant ($P<.01$) in both experiments. When fed with creatine, vitamin B_{12} also significantly ($P<.05$) improved crude fiber digestibility. Creatine, creatinine, sarcosine and urea were also studied *in vitro* in regard to N utilization, degradation products and possible metabolic pathways.

75. URINARY AND BLOOD CREATININE AS MEASURES OF LEANNESS FOR LIVE SWINE. R. L. Saffle, L. E. Orme, D. D. Sutton, D. E. Ullrey and A. M. Pearson, *Michigan State University*.

This study was undertaken to explore the usefulness of urinary and blood creatinine for predicting leanness of live hogs. Urine was collected from 35 hogs for 5 consecutive days. Blood samples were taken before and after each collection period. The amount of creatinine was determined by modifications of the method of Folin. Urinary creatinine was expressed in terms of the creatinine coefficient. The hogs were slaughtered and various physical measurements, carcass cut-out and chemical composition of the right ham were taken. Correlation coefficients were calculated with both level of blood plasma creatinine and the creatinine coefficient and the various measures of leanness or fatness. The correlations for the creatinine coefficient were —.61 for live probe, —.65 for backfat thickness, —.54 for fat trim, +.65 for lean cuts—carcass basis, +.66 for loin lean area of the last rib, +.55 for loin area 10th rib, +.41 for specific gravity of ham, —.58 for percent fat in ham, +.65 for percent water in ham and +.63 for percent protein in ham. The correlation coefficients of blood plasma creatinine ranged from a high of —.43 for percent fat trim to a low of +.08 for specific gravity of the ham. Results indicate that both creatinine coefficient and blood plasma creatinine can be used to predict leanness in live hogs, although the creatinine coefficient was more closely related to the various measures of leanness.

76. ANTIBODY ABSORPTION IN THE BABY PIG. V. C. Speer, H. Brown, L. Y. Quinn and D. V. Catron, *Iowa State College*.

The length of time after birth that domestic farm animals absorb ingested antibodies has been assumed to be a few days at most. Recently Petersen and Campbell (1955) reported absorption of antibodies from cow's milk that contained a high titer

for *Salmonella pullorum* when orally fed to 5 month old calves, adult humans, and adult pigs. This apparent contradiction of early work is of importance to the swine producer, because it brings up the question as to the advisability of early weaning baby pigs compared to the standard practice of eight week weaning from the standpoint of acquired immunity. High titer colostrum was collected from sows which were injected weekly with a standardized 0.2% formalin solution of *E. coli* starting approximately five weeks before farrowing. Baby pigs farrowed by control sows were then dosed *per os* with the high titer colostrum. Blood serum samples were collected immediately before dosing and 12 hours after dosing. Previous work at this station showed that maximal antibody absorption occurred within approximately 24 hours after birth. Therefore, in this test different pigs from the same litter were orally dosed with high titer colostrum at 6-hour intervals starting at birth through 36 hours after birth; one pig from each of eight litters was used as a control. Absorption of immune bodies was measured by a modified sheep red blood cell hemagglutination test. The serum hemagglutination titers showed a decreasing quadratic response curve with respect to time after birth. "T" tests between initial and subsequent serum titers were significant for the 0-, 6-, 12- and 18-hour groups, but were not significantly different for the 24-, 30- and 36-hour groups.

77. THE EFFECT OF TWO ENVIRONMENTAL TEMPERATURES AND FASTING ON BLOOD FAT LEVELS OF SWINE. R. E. Morrow, E. P. Reineke, A. M. Pearson and J. A. Hoefer, *Michigan State University*.

Blood fat levels of pigs held at a constant temperature of 80° F. and subjected to a constant feed intake for a period of 56 hours were not significantly different from those of fasted pigs under similar conditions. Blood fat levels of fasted pigs increased slightly during prolonged sampling. At the termination of the 56-hour fasting period, blood fat levels were reduced significantly ($P=<.01$) within 8 hours after feeding. The blood fat levels of the control pigs remained relatively constant. In another experiment, pigs were maintained in two temperature controlled laboratories at 40° F. and 80° F., respectively, and after 28 hours each group was reversed. Blood fat levels were run at 4 hour intervals throughout the experiment. Pigs held at 40° F. showed higher blood fat levels in the initial sample following acclimation than similar pigs held at 80° F., indicating that temperature causes variation in blood fat levels. These blood fat levels were significantly different at the 1% level. Following rotation, blood fat levels of the pigs previously held at 40° F. were reduced, but without the sharp reduction noted before, possibly due in part to the stress provoked by continued sampling. The blood fat levels of pigs rotated from 80° F. to 40° F. were increased again but without the sharp increase noted in the initial sampling.

78. ALTERATIONS IN BLOOD CONSTITUENTS OF CATTLE DURING BLOAT. H. D. Jackson, R. A. Shaw, W. R. Pritchard and B. W. Hatcher, *Purdue University*.

Twelve head of cattle of mixed breeding were subjected to bloat by pasturing for two two-hour periods each day following an overnight fast. The animals were grazed on first growth alfalfa pasture for 12 days, and then on blue grass pasture for 12 days. After each grazing period the cattle were graded for bloat. On the alfalfa pasture, 64 individual cases of bloat were observed: 19 cases in the morning and 45 cases in the afternoon. Blood samples were obtained before pasturing each morning and again following the afternoon grazing. The blood was analyzed for plasma total cholesterol, plasma ascorbic acid and red-cell cholinesterase activity. Differences between the morning and afternoon blood samples were used to study the effects of the grazing. Alfalfa pasture caused increased plasma cholesterol when bloat was observed and the cholesterol values were highest with greater severity of bloat. Blue grass pasture caused little change in the plasma cholesterol of the cattle. Neither pasture appreciably altered plasma ascorbic acid or red-cell cholinesterase activity.

79. EFFECTIVENESS AND PRACTICABILITY OF SOME OILS, PENICILLIN, DECYL ALCOHOL, AND LECITHIN IN THE CONTROL OF ALFALFA BLOAT. R. H. Johnson, L. R. Brown, N. L. Jacobson and P. G. Homeyer, *Iowa State College.*

During 4-week trials, three groups of steers (initial total 36, averaging 556 lb.) on alfalfa pasture of high bloat-producing potential received 0.75–1.5 lb. of grain or grain mixed with preventive preceding each grazing period. Animals were on pasture from 6:30 to 10 a.m. and from 4:30 to 8 p.m. In trial I, a water-dispersible lard oil (LO) mixed in the grain (0.5 lb./day) or in the drinking water (2% by weight; average daily consumption, 0.65 lb.) substantially reduced bloat severity. The oil-grain method gave the best protection. Daily weight gains were 1.99 (oil-water), 1.82 (oil-grain), and 1.24 lb. (control). In trial II, 0.5 lb./day of soybean oil (SBO) in grain greatly reduced bloat. A penicillin feeding supplement added to the morning grain (75 mg. procaine penicillin/day) reduced bloating as efficiently as SBO for nine days; thereafter a sharp decrease in efficiency was noted. Increasing to 125 mg./day again approximated the effects of SBO but efficacy decreased after two days. Daily weight gains were 1.54 (SBO), 1.26 (penicillin) and 0.82 lb. (control). Early results in trial III indicate that a mixture of lecithin (0.375 lb./day) and SBO or LO (0.125 lb./day) in the grain reduces bloat severity. Twenty-two dairy animals confined to dry lot and receiving alfalfa soilage were divided into comparable groups. SBO (0.25 lb./day/1000 lb. body weight) sprayed on the soilage substantially reduced bloat. No differences in weight gains were observed. Early results indicate that n-decyl alcohol (18 ml./1000 lb. body weight) prevents bloat for about two hours.

80. ESTIMATES OF GENETIC AND PHENOTYPIC PARAMETERS FOR USE IN A FARM FLOCK EWE SELECTION INDEX. V. L. Felts, A. B. Chapman and A. L. Pope, *University of Wisconsin.*

Data used in this study were obtained from farm flocks cooperating in the Wisconsin Sheep Improvement Program. Records from 32 flocks were used in the analysis. Lamb weights were adjusted to 120 days of age. Constants were fitted on a within year and flock basis for the effects of age of dam and type of birth (and rearing) on 120-day lamb weight. Because a "significant" interaction between age of dam and type of birth for 120-day weight was found in only 3 of the 74 flock-years it was assumed to be unimportantly small or non-existent. Pooled type of birth effects were 7.9, —2.3, 1.9, 2.8, —7.1, and —3.2 for male single, male twin, male twin raised as a single, female single, female twin and female twin raised as a single, respectively. As age of dam effect may be biased by selection, it was estimated from the average of the results based on the records of all ewes combined with the results based on those ewes with 2 or more consecutive records. These average constants were —14.26, .08, 4.23, 4.57, 3.73, 2.00 and —.34 for age of dam, in years, from 1 to 7. Regression of fleece weight on age, in years, was —0.2 lb. and number of lambs born on age was .04 of a lamb using records from 2 to 7 year old ewes. Intra-herd and intra-year variances of 120-day lamb weight, fleece weight and number of lambs born were 108.77, 2.19 and .163. Repeatabilities of the same characters were .313, .176 and .243 and heritabilities were .145, .386 and .068.

81. STUDIES OF BUYER PREFERENCES IN PURCHASING BOARS OF KNOWN MERIT. Ralph M. Durham and L. N. Hazel, *Iowa State College.*

Boars from the Iowa Swine Testing Station are given an index score based on their backfat, efficiency and daily gain. In each of three testing seasons approximately 2/3 of the boars have been sold at auction, and the lower 1/3 have been castrated. The sale order of boars within each sale has been according to index, with the highest

indexing boar selling first and the lowest indexing boar selling last. Data on sale prices of 317 boars sold in six sales and including the August 6, 1957 sale, have been analyzed for the regression of price on index. There has been a rather steady trend for this positive regression to increase throughout the six sales. The regressions for the two sales held in each season have been averaged. The average regression of price on index for the first season's sales was $3.69 per point. This can be compared with the figure of $4.64 for the second two and $6.20 for the third pair of sales. Mean averages for the first, second and third sales are $164, $176 and $251 respectively. Possible explanations for the apparent upward trend of the price-index regression are (1) experience and learning on the part of boar buyers as to what the index means. (2) Increased general interest in records as a basis for improvement, over the commonly used "eye" method. (3) Gradual tendency for merit buying of market hogs, which is reflected in demand for better boars. (4) Increasing interest among purebred breeders in buying tested boars. Breeders are willing to pay large prices for high indexing boars, thus spreading out the range of prices.

82. FULL VS. LIMITED FEEDING AS RELATED TO THE IMPROVEMENT OF ANIMALS FOR MEAT PRODUCTION THROUGH BREEDING. Stewart H. Fowler and M. E. Ensminger, *State College of Washington.*

This study was started in 1947 with a foundation stock created by crossing five Danish Landrace boars with five unrelated groups of Chester White sows. The offspring from each group were divided into two lines: one line was full-fed from weaning to 150 lb.; the other line was fed 70% as much as the full-fed pigs ate at comparable weights. After six generations, one-half of the pigs in each line were shifted to the other plane of nutrition, thus forming four lines—high-high (HH), high-low (HL), low-low (LL), and low-high (LH). The study is now in the tenth generation. At 150 lb., detailed body measurements are secured, and the animals are indexed, taking into account fertility, survival, and rate of gain. The highest indexed animals are saved to produce the next generation, with no attention given to type. Analysis of the data for the first nine generations revealed a highly significant difference in rate of gain in favor of full-fed pigs, but limited-fed pigs have excelled throughout on feed efficiency. When limited-fed pigs were shifted to full-feeding (LH), they were superior in rate and economy of gain when compared to the full-fed pigs with a background of continuous full-feeding (HH). Pigs with a history of continuous limited-feeding (LL) excelled in rate and economy of gain when compared to limited-fed pigs from a background of full feeding (HL). For 150-lb. body measurements, full-fed pigs were consistently significantly wider across the loin, and limited-fed pigs were significantly taller. Such measurements as length and depth of body and width of shoulder and ham were not consistently affected by plane of nutrition.

83. EARLY DEVELOPMENT OF THE MINNESOTA NO. 3 LINE OF SWINE. L. J. Sumption, W. E. Rempel and L. M. Winters, *University of Minnesota.*

Five generations of development were described and evaluated including data on 267 spring-farrowed litters; 222 litters of 1653 pigs were performance tested. Twelve basic breeds were incorporated by combining inbred lines, and outbred breeds. Estimated composition of the F_5 population was: 31% Gloucestershire Old Spot, 20% "C" Line Inbred Poland China, 14% Welsh, 12% Large White, 7% Beltsville No. 2, 6% Minnesota No. 1, 5% Minnesota No. 2 and 5% San Pierre. Management methods were designed to capitalize on natural selection. Multiple sire mating has been standard procedure. Spring litters were farrowed outdoors with minimum care. The average generation interval was 0.98 yr. Estimated inbreeding and inter-se relationship of the F_5 was 0.14 and 0.33 respectively. Average selection differentials were 1.23, 1.76, 4.24 lb., 13.05 lb. and 0.11 lb. for number born, number weaned, 56 day weight, 140

day weight and rate of gain respectively. Selection was effective in the early development of the line as indicated by time trends in performance and expected genetic gain. There was a significant positive shift in the frequency distribution of 56 day and 140 day weights; litter size remained unchanged. A level of performance similar to the F_1 has been maintained under slow inbreeding. Genetic improvement of economic traits can be made provided: (1) the breeder begins with sufficient genetic variation, preferably by crossing breeds, (2) the rate of inbreeding permits extensive recombination, (3) population size is sufficient to evaluate new combinations in numbers, and (4) rigorous selection is practiced with specific objectives. Description of the line will be illustrated.

84. FURTHER STUDIES ON THE USE OF THE PROBING TECHNIQUE IN SELECTING BREEDING SWINE ON FARMS. J. X. King, J. H. Zeller, H. O. Hetzer and W. R. Harvey, *A. R. S., U.S.D.A., Beltsville, Maryland.*

Measurements of backfat thickness were obtained for 4041 hogs from 56 herds in five states—Illinois, Indiana, Michigan, Ohio, Pennsylvania—during the years 1954, 1955 and 1956 as part of a project for the identification and certification of meat type hogs. Probing and weight records for 3648 of these hogs (1597 boars and 2051 gilts) from eight breeds were used in the analysis. Backfat measurements were adjusted to the basis of gilts at an average weight of 200 lb. and an average age of 186 days, using a multiple regression analysis. Individual weights were adjusted to a standard age of 180 days, using a formula given by Whatley (1942). Constants representing the effects of seasonal, yearly and farm differences were calculated in order to correct backfat and weight data for effects of identifiable environmental factors. Backfat thickness averaged 1.45 in. for the 3648 pigs studied, while 180-day weight averaged 193 lb. The corresponding averages for the eight breeds varied from 1.28 to 1.62 in. and from 171 to 204 lb., respectively. Selection differentials based on records for 19 boars and 71 gilts were negative for backfat thickness and positive for 180-day weight, indicating that selection based on probe and weight records was for leaner and faster growing animals. Heritability estimates calculated by the paternal half-sib method were 42% for backfat thickness and 18% for 180-day weight.

85. PROBLEMS INVOLVED IN USING A MILK METERING DEVICE. E. W. Hupp, J. P. Dietrich, W. W. Snyder and R. C. Lewis, *Michigan State University.*

Several problems have been encountered in using a pipeline milk metering device, known commercially as the Milk-o-Meter. In testing this device, the individual meter weights were checked against the weight of the milk on a platform scale, the accuracy of which had been verified. During the year several models have been tested, however, the basic principle of the weighing device remained the same. In 5 separate trials, comprising 264 individual observations, the mean error in estimating daily production was 1.63%. Only 9.85% of these observations had an error greater than 3%. One of the sources of error was the variation in rate of milk flow between cows. The meters tested consistently underestimated the production of fast milking cows. In a trial with 26 observations on 5 cows having an average maximum flow rate of 9.6 lb. per/min., the mean error was —1.87% while in another trial with 36 observations on 9 cows having an average maximum rate of flow of 4.0 lb. per min. the mean error was only 0.95%. Improper mounting and leveling of the meter, and excessive vibration of the meter with one type of low vacuum milking machine resulted in excessive errors. In 54 observations on the butterfat sampling device designed for this meter, the mean difference between composites of 2 milkings drawn from the sampler and those taken in the conventional manner was 0.79%. Of these only 5.56% differed by more than 0.2% in butterfat test. When properly operated, this metering and sampling device can be used for measuring the individual cow production.

86. A GRAPHIC REPRESENTATION OF THE GRADES FOR LIVESTOCK AND MEAT. Robert Reierson, *University of Wisconsin.*

A large part of the educational efforts aimed at improving skills of selection, grading and placing of slaughter and feeder livestock is based first, on a clear understanding of the standards for grades of livestock and meat; and second, on a uniform application of the grades. The lack of uniformity of application of grades slows the overall improvement of the grade and quality of livestock. To the extent that two characteristics can be selected which are the main determinants of grades, a graphic representation may be presented to make the grades more readily understandable and more uinformly applicable. Using beef grades as an example of this, the relationship of one grade to another can be shown on one page of graph paper or on one slide by putting the degrees of marbling on the Y axis and the approximate age or degrees of ossification on the X axis. The various grades can then be boxed in on the body of the slide or graph to indicate the various combinations of factors involved in each grade, and will result in slanting lines between grades. This method allows a clearer demonstration and understanding of the influence of each of these two factors on grade, and the relationships between the grades of beef. In order to use this method with various classes of livestock and meat, degrees of the two factors being used must, to some extent, be substitutable for each other.

87. A PERFORMANCE TESTING PROGRAM WITH PUREBRED SHEEP. M. P. Botkin, E. K. Faulkner and P. O. Stratton, *University of Wyoming.*

The University of Wyoming has established a cooperative performance testing program with sheep breeders in the state. In cooperation with the Extension Service, breeders collect performance data at weaning, which is sent in to the Animal Production Department for analysis. Traits measured include: body weight, type score, face covering score, score for wrinkles, staple length, fleece density score, and fleece uniformity score. All scores range from 1 to 10 with 10 being the most desirable. Weaning weights are corrected for the influence of age, sex, type of birth, and age of dam. Staple lengths are corrected for the influence of age. After corrections have been made, an index is determined for each lamb, combining all the data available. Although the index is flexible from year to year or from flock to flock, an attempt is made to keep the emphasis on various traits in line with their importance. For instance, in the case of Rambouillets, Columbias or Corriedales, about 2/3 of the emphasis is placed on size and conformation or appearance, and 1/3 placed on fleece characteristics. An example of the index now in use for Rambouillets is as follows: corrected weaning weight +5 times type score and wrinkles score and face covering score +½ staple length (in mm.) +2 times density score +2 times uniformity score. This information is returned to the breeder to be used as an aid in selection. Since this work has been with purebred flocks, any obvious defect or failure to meet breed character specifications are disqualifications and lambs may be culled regardless of their index.

88. DIETARY FACTORS RELATED TO MUSCULAR DYSTROPHY IN LAMBS. D. E. Hogue, R. G. Warner, J. K. Loosli and J. P. Willman, *Cornell University.*

Following breeding on pasture in the fall of 1955, 64 grade ewes were divided into four groups. All groups received a trefoil-grass hay and a concentrate as follows: (1) raw cull kidney beans, (2) cooked beans, (3) raw beans DPPD (0.025% of the total ration), (4) corn, oats, wheat bran and linseed meal (4:3:2:1). In addition, 24 ewes that had not been on pasture since 1952 were divided into two groups and fed as follows: (5) trefoil-grass hay raw beans, (6) alfalfa-grass hay raw beans. The incidence of diagnosed muscular dystrophy (m.d.) in the lambs the following spring was 30, 6, 60, 0, 31, and 31%, respectively. Diets 1 through 4 were repeated in 1956–57 with the incidence of m.d. being 37, 11, 20, and 0%, respectively. Plasma tocopherol

values of both ewes and lambs were determined periodically following lambing in 1955–56. These values did not reflect the incidence of m.d. as all were low (30–80 mcg. per 100 ml.). The biological tocopherol value of the cooked beans and the concentrate mix was determined by a chick assay. Chemical determination on similar lots of feeds indicated the tocopherol values to be 0–5 and 2–5 mg. per lb., respectively. The biological value of the beans was 6–15 mg. per lb. and of the concentrate mix was 50–100 mg. per lb. Further study of the individual components of the concentrate mix has indicated that the corn, oats, wheat bran and linseed meal have biological values of 50, 50, 120, and 90 mg. per lb., respectively. These values are higher than chemical values reported for such feeds. Factors in natural feeds other than tocopherol are apparently involved in preventing m.d. in lambs.

89. UTILIZATION BY LAMBS OF SEMI-PURIFIED RATIONS CONTAINING DIFFERENT LEVELS AND SOURCES OF ROUGHAGE. G. S. Smith, G. A. McLaren, G. C. Anderson, J. A. Welch and C. D. Campbell, *West Virginia University*.

Reports from this Station have shown that the utilization of NPN by lambs is influenced by such factors as length of preliminary period and the feeding of diethylstilbestrol or vitamin B_{12}. The present study was conducted to ascertain the influences of level and source of roughage upon nitrogen utilization and ration digestibility. The rations fed were composed of purified concentrate mixtures, cane molasses and either wheat straw or other roughages. The rations contained 1.7% nitrogen, two-thirds of which was supplied as urea, and were approximately isocaloric. In Trial I, varied levels of wheat straw provided three rations containing 20.0, 24.7 and 28.6% of crude fiber. Digestibility of organic matter and NFE was depressed by the higher levels of roughage, while crude protein and crude fiber was not significantly affected. Nitrogen balances were maintained, and were approximately equal with the medium and high fiber levels, but were decidedly improved by the low fiber ration. Utilization of nitrogen was improved ($P<.01$) by the low fiber ration, but was not significantly different between the medium and high fiber rations. Fecal nitrogens from the high and low fiber rations were equal, and greater than those of the intermediate level. In Trial II, wheat straw alone or in combination with equal amounts of either oat hulls, corncobs, or bagasse pith constituted 53% of the ration dry matter. Digestibility of organic matter, crude fiber and NFE was improved ($P<.01$) by corncobs and depressed by oat hulls ($P<.01$) and bagasse pith ($P<.05$). No differences in the digestibility of crude protein resulted. Positive nitrogen balances were maintained with all rations but oat hulls depressed the utilization of nitrogen.

90. UTILIZATION OF DIETARY MAGNESIUM BY CALVES FED DIFFERENT PROTEINS. George E. Hawkins, *Alabama Poylytechnic Institute*.

Recent reports by other investigators suggest that the rate of deamination of proteins in the rumen may affect utilization of dietary Mg by dairy animals. A study, involving 12 dairy calves approximately 60 days of age at the start, was made to evaluate the effect of source of principal protein on utilization of dietary Mg. The control diet consisted of 16.7% mixed proteins and the principal proteins, which made up an average of 27.5% of the test diets, were: I, casein; II, zein; and III, corn gluten. Mean Mg contents of the diets were: control, 0.079%; I, 0.073%; II, 0.073%; and III, 0.073%. Average Mg levels in blood serum from calves, during the age range 160 to 187 days, fed the experimental diets expressed in mg. per 100 ml. were: control, 1.8; I, 1.8; II, 1.7; and III, 1.9. These blood serum values did not differ significantly. The experiment was terminated June 27, 1957, at which time some of the calves were 260 days of age. On this date the average blood serum Mg levels by diets were: control,

2.0; I, 2.2; II, 2.0; and III, 2.2. The blood serum Mg levels indicate that casein, which reportedly is more readily deaminated in rumen liquor than zein and corn gluten, did not increase the dietary requirement for Mg. Also, it appears that the 0.07 to 0.08% dietary Mg fed in this study was adequate to meet the minimum nutritional requirements of the calves.

91. PROTEIN-ENERGY RATIOS FOR FATTENING CATTLE. J. Matsushima, R. W. Rice, T. W. Dowe and C. H. Adams, *University of Nebraska.*

Nine lots of five steers each were fed three levels of protein and energy in a 3x3 factorial experiment. Choice yearling Hereford steers were individually fed for 211 days. The medium level protein and medium level energy rations were calculated to provide these nutrients in the amounts recommended by the National Research Council. The rations with low levels of protein and energy were calculated to be approximately 18% and 10%, respectively, below the recommended levels. The high levels of protein and energy were approximately 18% and 10%, respectively, above the recommended levels. The basal ration consisted of ground shelled corn, dried molasses, soybean oil meal, ground corncobs and chopped alfalfa hay. Urea and stabilized prime beef tallow were used to adjust the protein and energy levels in the rations. The largest average daily gain (2.06 lb.) was made by the group fed the high protein-medium energy ration while the lowest gain (1.63 lb.) was made by the low protein-high energy fed steers. The efficiency of feed utilization increased as the level of energy and protein in the ration increased. Highest carcass grades and dressing percentages were observed in the medium protein-medium energy and low protein-medium energy groups and were lowest in the high protein-low energy group. Digestion trials were conducted concurrently with the feeding trial. Fiber digestibility was decreased and ether extract digestibility was increased as the energy level in the ration was increased. Apparent nitrogen retention was not affected significantly by the protein-energy ratios used in this test.

92. THE EFFECT OF VARIED CELLULOSE AND NITROGEN LEVELS UPON THE DIGESTIBILITY OF SEMI-PURIFIED RATIONS FED TO LAMBS. W. C. Ellis and W. H. Pfander, *Missouri University.*

Thirty-six metabolism trials were conducted with twelve lambs fed semi-purified rations. Solka Floc, Drackett C-1 assay protein, and starch levels were varied to provide rations containing either 21.4, 31.4, or 41.6% cellulose and 1.65, 2.05, or 2.45% nitrogen. The remaining constituents were held constant. Increasing cellulose linearly depressed ($P<0.005$) the digestibility of organic matter (OM), nitrogen-free-extract (NFE), and ration total digestible nutrients (TDN); linearly increased the digestibility of cellulose ($P=0.05$) and ether extract ($P<0.005$), and unaffected nitrogen digestibility. Significantly higher ($P<0.05$) digestibilities of cellulose, OM, NFE, nitrogen, and ration TDN content occurred in 2.05% nitrogen rations than in either 1.65 or 2.45% nitrogen rations. Partial coefficients of correlation (r) and regression coefficients (b) for cellulose and NFE level upon OM digestibility were respectively: $r=-0.647$ and $+0.672$, $b=-0.44$ and $+0.40$. The small regression coefficient for cellulose on OM digestibility, compared to that reported for natural rations, lends support to the "envelopement" concept. Regression coefficients for cellulose on OM digestibility and cellulose on non-cellulose OM digestibility were significantly different ($P=0.05$). Depressive effects of increasing cellulose levels on OM digestibility were, therefore, due to (1) a dilution of highly digestible OM with poorly digestible cellulose OM and (2) a depressive effect on non-cellulose OM digestibility.

93. DIGESTIBILITY OF BROMEGRASS HAYS GROWN UNDER VARIOUS LEVELS OF NITROGEN FERTILIZATION. R. A. Markley, J. L. Cason and B. R. Baumgardt, *New Jersey Agriculture Experiment Station.*

Four 18 month old dairy heifers were used in a total collection digestion trial, 10-day preliminary and 7-day collection periods, employing a latin-square design

balanced for residual effects with an extra period added to more effectively estimate carry-over effects. The 4 rations, fed twice daily, were second cutting hays—alfalfa and 3 bromegrass hays, the latter grown with 25, 125, and 225 lb. N per acre, respectively. A N-balance was determined for each hay. The crude protein and digestion coefficient of protein for alfalfa was 17.31% and 73.16%; brome grass hays—25 lb. N per acre, 7.46% and 61.77%; 125# N per acre, 12.45% and 66.55%; 225 lb. N per acre, 17.16% and 74.33%, respectively. Ether extract followed a trend similar to protein while the percent fiber and NFE decreased with increasing nitrogen fertilization. The digestibility of energy, protein, ether extract, and fiber increased while that of NFE decreased with increasing nitrogen fertilization of brome grass. Digestibility of the fiber of alfalfa was about 42%, while the average for the brome grass hays was approximately 64%. The TDN and digestible energy content (calories per gram) of alfalfa was 49.79% and 2410; brome grass may—25 lb. N per acre; 54.10% and 2427; 125 lb. N per acre, 53.15 and 2469; 225 lb. N per acre, 56.35 and 2691, respectively. Chemical and statistical analyses will be presented.

94. *IN VIVO* STUDIES OF THE CELLULOLYTIC FACTOR(S) PRESENT IN DISTILLERS DRIED SOLUBLES. F. H. Baker, R. B. Grainger and J. W. Stroud, *Kentucky Agricultural Experiment Station.*

A conventional digestion-nitrogen-balance trial with 6 groups of wethers (4 per group) was conducted to further characterize the cellulolytic properties of distillers dried solubles (DDS). The basal ration fed to the wethers in Group I was composed of cottonseed hulls, 78.0%; Drackett protein, 6.0; urea, 1.2; corn starch, 8.4; corn oil, 3.0; salt, 0.5; $CaHPO_4$, 1.4; $MgSO_4$, 0.2; sulfur, 0.01; and vitamin A & D concentrate, 0.03. Chemical fractions of DDS included in the rations were: Group II, $CHCl_3$ extract; Group III, residue of $CHCl_3$ extraction; Group IV, H_2O extract of residue from $CHCl_3$ extraction; Group V, residue from the aforementioned H_2O extraction. For the ration of Group VI, 16.8% DDS was substituted into the basal ration for an equivalent amount of organic matter, crude cellulose, ether extract and digestible protein. The chemical fractions of DDS were fed at levels equivalent to that contained in 16.8% DDS. The mean apparent digestion coefficients for crude cellulose from the rations were: Group I, 54.9%; II, 55.9; III, 61.6; IV, 58.8; V, 59.4; VI, 64.0. Thus DDS per se and all fractions except $CHCl_3$ extract significantly improved the digestibility of cellulose of the basal ration. The differences between $CHCl_3$ extract and residue of $CHCl_3$ extraction of DDS per se were highly significant. These results combined with those of earlier trials demonstrate that the cellulolytic factor(s) contained in distillers dried solubles is organic in nature and is associated with the protein and/or the carbohydrate fractions.

95. FEEDING VALUE AND ACTIVITY OF DRIED RUMEN PRODUCTS. L. D. Kamstra, P. R. Zimmer and L. B. Embry, *South Dakota State College.*

Dried rumen products were tested by use of *in vitro* and *in vivo* studies. One gram of the dried rumen products digested from 0 to 12% of an initial 1 gm. sample of purified wood cellulose over a 24 hour period. Forty milliliters of fresh rumen juice with a similar diet digested 60% of initial substrate during the same period and was not improved by the addition of 1 gm. of dried rumen product. Diet additions normally used for studies with washed cells were used in these experiments. The *in vitro* activity of the rumen flora of sheep receiving dried rumen product in the feed (1 gm. per head daily) was determined periodically over an eleven week period by removing samples of rumen ingesta from cannulated sheep. The ability to digest cellulose over a 24-hour period was not improved by the supplementation of high-roughage or high-concentrate rations. Two groups of 4 wether lambs were used in determining the effects of dried rumen products (1 gm. per head daily) on feed efficiency, rate of gain and

digestibility of the rations. A ration of oats (75%) and alfalfa hay was fed for an 8-week period with controls and supplemented lambs making the same average daily gain (0.38 lb.) with no difference in feed efficiency. A digestion trial showed a slight advantage in apparent digestion coefficients of all nutrients for the control lambs with the largest difference being in crude fiber (27.83% and 33.59%). Rate of gain and feed efficiency was not improved by the dried rumen product when the ration was changed to 75% alfalfa hay and 25% oats.

96. EFFECT OF ANISE OIL ON THE PALATABILITY OF CALF STARTERS. W. J. Miller, J. L. Carmon and H. L. Dalton, *The University of Georgia.*

Four cafeteria experiments involving 16 starters were conducted to determine the influence of anise oil on starter preference of young dairy calves. In the first experiment 0, 0.5 and 2 lb. per ton of an imitation anise oil (I.A.O.) were offered both with soybean oil meal and degossypolized cottonseed meal. Other principle ingredients were corn, oats, brown grease and hydrogenated cottonseed oil. Each of 3 calves consumed significantly more of the starter with no I.A.O. Percentages of total consumption were 82, 14 and 4 for the 0, .5 and 2 lb. per ton levels of I.A.O. In the second experiment 0 and .5 lb. per ton of I.A.O. were offered both with S.O.M. and degossypolized C.S.M. Other major ingredients were corn and citrus pulp. Of total starter eaten by 7 calves, 59% contained no I.A.O. In the third experiment major ingredients were citrus pulp and S.O.M. Eleven calves ate 30% more starter with no I.A.O. than starter containing .5 lb. per ton. The same 11 calves were used on alternate weeks in the fourth experiment in which the basal starter differed by the addition of brown grease and hydrogenated cottonseed oil. In order to be certain that the I.A.O. was not an atypical anise oil two others were compared at .5 lb. per ton. Percentages of starter consumption with the various anise oils were: control, 39; I.A.O. 24; U.S.P. anise oil, 19; and annol, 17. Only the last two were not significantly different.

97. THE CALORIC VALUE OF TDN. R. W. Swift, *Pennsylvania State University.*

The greater ease and accuracy of the determination of digestible energy as compared to that of TDN has long been recognized. The problem of the evaluation of large numbers of old TDN values in terms of energy, however, has been one of concern. Using data from 312 digestion experiments in which both digestible energy and total digestible nutrients were experimentally determined revealed that one lb. of total digestible nutrients is equivalent to 2000 Calories of digestible energy. This value was found to apply to sheep and cattle on roughage alone and to cattle on mixed rations.

98. EFFECT OF IRRIGATION AND OF TIME OF DAY ON COMPOSITION OF YOUNG ALFALFA. R. S. Allen, P. G. Homeyer, N. L. Jacobson, N. R. Gould, R. E. Worthington and R. H. Johnson, *Iowa State College.*

In experiment I, 4-inch tops of pre-bloom alfalfa were taken by a stratified random sampling procedure from non-irrigated plots and from plots on which irrigation (sprinkling—5.5 inches water over a 7–8 hour period) had been completed approximately ½, 9, 18, 27 and 37 hours before sampling. To study the effect of time of day on composition (experiment II), pre-bloom alfalfa was sampled (stratified random) at 6 a.m., 10 a.m., 2 p.m., 6 p.m. and 10 p.m. All samples were analyzed for dry matter, nitrogen (non-protein, amino and total), reducing sugars, ash and phosphorus. Samples in experiment II also were analyzed for total and certain non-volatile organic acids. Irrigation had little effect on reducing sugar, total nitrogen, ash and phosphorus values, whereas there was a significant increase in non-protein nitrogen with increasing time after irrigation and a gradual but limited increase in amino nitrogen. Diurnal variation was greatest for the reducing sugar, ash and phosphorus.

Reducing sugars increased to a maximum at 2 p.m., then declined; ash, phosphorus and total nitrogen values declined to a minimum at 6 p.m., then increased. Total non-volatile organic acids were lowest at 6 a.m., reached a maximum at 10 a.m. and remained relatively high with malic, malonic and citric acids predominating. Succinic, fumaric and several unidentified acids were present in small amounts.

99. VOLUNTARY INTAKE OF FORAGE AS A MEASURE OF ITS FEEDING VALUE. E. W. Crampton, E. E. Lister and L. E. Lloyd, *Macdonald College (McGill University), Canada.*

To determine the usefulness of voluntary forage intake in evaluating forages nutritionally, five sheep were fed ad libitum five pure forage species. These forages included Birdsfoot trefoil, Bromegrass, Oat straw, Red clover and Timothy. Each forage was fed to each sheep for a period of eight weeks. The amount of forage an animal will voluntarily consume was found to differ between forage species. The differences in level of intake depended upon body weight and forage content of protein, phosphorus and crude fiber. Voluntary forage intake proved to be a measure of rate of digestion. In addition, voluntary forage intake was found to be a more precise criterion of forage feeding value than either TDN or crude fiber content of forage.

100. UTILIZATION OF MEADOW CROPS FOR THE PRODUCTION OF GOOD TO CHOICE SLAUGHTER BEEF. Earle W. Klosterman and L. E. Kunkle, *Ohio Agricultural Experiment Station.*

For three years, different ages of feeder steers and various methods of feeding were compared to determine which age and/or method would make the maximum and most profitable use of meadow crops. Yearling steers fed corn silage, supplement and hay produced the most beef per acre of total cropland and the greatest return for the meadow crop utilized but consumed only a limited amount of meadow crop. Yearling steers fed a half feed of ground ear corn, hay-crop silage and hay produced slightly more beef per acre and a higher return for the meadow crop utilized than similar steers fed the same ration without hay-crop silage. Steer calves utilized less meadow crop per head but produced more beef per acre and a greater return per acre of meadow crop than yearling steers when fed the half feed of corn, hay-crop silage and hay ration. Of the total TDN consumed, the highest percentage supplied by meadow crops and the largest area of meadow crop utilized per head were obtained with steer calves wintered on hay-crop silage, hay and limited corn, grazed and then fed corn on pasture the following summer. Returns per acre of meadow crop utilized with these cattle compared very favorably with the calves fattened in dry lot on hay, hay-crop silage and corn even though they tended to grade slightly lower. Values of the cattle at the end of the experiments were determined from actual carcass grades and weights. Returns calculated were gross returns without consideration of harvesting, storing and feeding costs.

101. HIGH LEVELS OF GRASS SILAGE FOR MILK PRODUCTION, WITH NO GRAIN, MEDIUM AND HIGH GRAIN FEEDING. R. E. Mather, C. P. Breidenstein, B. R. Poulton and G. H. Bonnington, Jr., *New Jersey Agricultural Experiment Station.*

In a three-lactation study with 18 Holstein and 6 Guernsey cows early-cut molasses grass silage was fed ad libitum four times daily in addition to 5 lb. alfalfa hay. In summer, pasture replaced silage. Three levels of feeding were used: no grain, 1 lb. grain per 6 lb. 4% FCM, and 1 lb. grain per 3 lb. FCM. One half of the cows received the same rations continuously for three lactations; the other half was on a latin square changeover balanced for carryover effects. Milk production (4% FCM)

in 245 days by the continuous cows was 8,254, 10,758, and 13,763 lb. respectively, which was 78, 97, and 124% of estimated potential (10,928 lb.), and 6,727, 8,164, and 9,334 lb. for the reversal cows or 76, 92, and 106% of potential (8,829 lb.). Average silage consumption was 82, 74, and 69 lb. daily on the three rations. For the no-grain roughage dry matter consumption was 2.12 lb. per 100 lb. body weight. With the higher producing (continuous) cows, increasing grain from 1:6 to 1:3 produced 1.32 lb. milk per lb. gain, while for the lower producing (reversal) cows, this change resulted in only 0.75 lb. of milk per lb. grain. Differences in production among rations were not significant when adjusted for either TDN or estimated net energy intake. In the barn period (continuous group) 1 lb. FCM resulted from 0.26 lb. TDN or 0.26 therms estimated net energy.

102. THE NUTRITIVE VALUE OF NITROGEN-FERTILIZED ORCHARD GRASS HAY AS COMPARED TO ALFALFA HAY USING MILK PRODUCTION AS A MEASURE. Carroll H. Ramage, Emil F. Ogrinz, Claude Eby and Robert E. Mather, *New Jersey Agricultural Experiment Station.*

Using a special adaptation of the double reversal design for 3 treatments, 12 cows (8 Holsteins and 4 Guernseys) were fed 3 rations containing 3 different hays. All cows were fed 20 lb. of grass silage daily, and received grain at the rate of 1 lb. per 4 lb. of 4% FCM produced. The amount of grain was changed weekly, with all cows having the same percentage change according to the overall average change in milk production. Low nitrogen orchard grass hay contained 12.4% protein, high nitrogen orchard grass hay had 14.7%, and second cutting alfalfa had 17.6% protein. Dry matter consumption of the 3 hays was 16.3, 17.6, and 19.2 lb. per day, respectively. Total dry matter consumption of the rations was 28.7, 30.5, and 31.7 lb. per day. In the 15 week period of the feeding trial 4% FCM production on the low nitrogen grass, high nitrogen grass, and alfalfa hay rations was 28.55, 28.52, and 30.47 lb. respectively. The alfalfa hay produced significantly more milk than the two grass hays. Body weight gains were 10.57, 39.32, and 3.52 lb. for the low nitrogen orchard grass, high nitrogen orchard grass, and alfalfa hays, with the high nitrogen grass producing significantly higher gains than the other two hays which were not significantly different. Using Schneider's regression coefficients (based on proximate analyses) to calculate percent TDN in the 3 hays, the following values were obtained: low nitrogen orchard-grass, 57.64% TDN; high nitrogen orchard grass, 64.98; and alfalfa, 57.71%.

103. COMPARISON OF FEEDING THREE FORAGES AS BALED HAY, CHOPPED HAY, HAY PELLETS AND SILAGE TO STEER CALVES. R. J. Webb, G. F. Cmarik and H. A. Cate, *University of Illinois, Dixon Springs Experiment Station.*

Alternate strips in a first year timothy-alfalfa mixture were harvested as baled hay and silage in the summer of 1955. Part of the baled hay was ground and pelleted, part chopped, and part left as baled hay. Sixty steer calves were divided into four lots of 15 each in the fall and fed as follows: Lot 1—baled hay, Lot 2—silage + chopped hay, Lot 3—hay pellets, Lot 4—chopped hay. Average daily gains in lb. were .63, .05, 1.73, and .62; daily dry matter intake 9.48, 6.13, 14.29 and 9.27; dry matter per cwt. gain 1498, 13505, 825 and 1492, respectively. It will be noted the performance of the calves fed hay pellets was outstanding. A ton of hay pellets produced 220.7 lb. gain, baled hay 115.5 lb. gain and chopped hay 116.2 lb. gain. In the winter 1956–57, 9 lots of 10 steer calves each were fed for a period of 112 days as follows: Lot 1—alfalfa hay pellets, Lot 2—alfalfa hay pellets + rumen additive, Lot 3—timothy-alfalfa hay pellets, Lot 4—Sericea lespedeza hay pellets, Lot 5—baled alfalfa hay, Lot 6—baled alfalfa hay + rumen additive, Lot 7—timothy alfalfa silage + long hay, Lot 8—timothy-alfalfa silage + long hay + rumen additive, Lot 9—baled Sericea

lespedeza hay. Average daily gains were 1.77, 1.82, 1.33, .38, .18, .43, .30, .27 and .21 lb. respectively. Pounds of dry matter required per 100 lb. gain were as follows: 792, 744, 970, 3087, 5160, 2275, 2503, 2721, and 4730, respectively. Again the efficient performance of hay pellets is indicated.

104. FACTORS AFFECTING WEIGHT GAIN OF HEIFERS WHEN FED HAY, SILAGE ON PASTURE. M. E. McCullough, L. R. Sisk, W. E. Neville, Jr. and O. E. Sell, *Georgia Experiment Station, Experiment.*

Factors affecting weight gains by dairy heifers were studied with 28 heifers on pasture and 10 individually fed heifers on either an all hay or grass silage ration. The heifers averaged about 450 lb. in weight. The only factor significantly correlated with gains on pasture, was forage dry matter digestibility (r=.797). On pasture the multiple correlation between average daily gains and dry matter digestibility, dry matter intake and body weight was .831. Over a 56-day feeding period, the correlations between dry matter intake and average daily gains were .711 for silage and .399 for hay. Correlations between body weight and dry matter intake were .932 for silage and .897 for hay. Multiple correlation between average daily gains, body weight and dry matter intake were .858 for silage and .463 for hay. Respective average daily gains for pasture, silage and hay were 1.79, .92 and 1.34 lb. The error of estimate of weight gains in all groups prevents accurate estimate of response from the factors measured and emphasizes the large number of animals required to show significant differences between rations. On an individually fed hay ration, 82, 14 and 4 animals per treatment were required to show significant differences in average daily gains of .10, .25 and .50 lb. between group means. On silage, 174, 28 and 7 animals were required to show the above differences. When the effect of body weight and dry matter intake of silage were removed, the number of animals needed was reduced to 72, 12 and 3. With grazing heifers to determine a significant difference of 1, 2 and 5% in dry matter digestibility would require 7, 2, and 1 animals respectively on all leaf pasture and 48, 12 and 2 animals on a stemmy pasture (leaf: steam ratio 1:3) where selective grazing was a factor. The data would appear to indicate that intake was a major factor only on the grass silage.

105. YIELD OF EVERGLADES PASTURES AS MEASURED BY GROWTH OF YEARLING CATTLE. R. W. Kidder, R. J. Allen, Jr., H. L. Chapman, Jr. and D. W. Beardsley, *Everglades Experiment Station, University of Florida.*

Five pairs of two-acre pastures were used in a five-year study to compare (1) growth of yearling cattle grazing Roselawn St. Augustinegrass (*Stenotaphrum secundatum* (Walt.) Kuntze) and the more frost sensitive paragrass (*Panicum purpurascens*, Raddi) and caribgrass (*Eriochola polystacha* H.B.K.) and (2) alternate vs. continuous grazing of Roselawn St. Augustinegrass. Yearling cattle, from 400 to 800 lb. in weight, were grazed on these grasses 12 months of each year. Individual weights were obtained every 14 days and the animals moved to the alternate pasture. Total average annual live weight gain per acre was 1004 lb. for St. Augustinegrass as compared to an average of 920 lb. per year for paragrass and caribgrass. The average annual carrying capacity per acre of these grasses was 2.76 yearling animals for St. Augustinegrass as compared to 2.61 for paragrass and caribgrass or 1.61 "thousand pound cow equivalents" for the former as compared to 1.25 for the latter grasses. Ninety to ninety-two percent of the average total gain per acre was realized from March through October with St. Augustinegrass proving superior during the spring months and paragrass and caribgrass producing more gain per acre during the months of July through October. Estimates of total digestible nutrients consumed were calculated from animal weights and gains.

106. INFLUENCE OF PROTEIN AND PHOSPHORUS SUPPLEMENTS ON RANGE CATTLE PRODUCTION. Lorin E. Harris, John E. Butcher, Lynn F. James and C. Wayne Cook, *Utah State University*.

Four hundred Hereford cattle, equal numbers of 2, 3, 4, and 5–8 year age groups, were stratified by age and allotted to the following treatments: (1) range forage only, (2) 8.0 gm. of phosphorus per day, supplemented in water, (3) 1.0 lb. of soybean oil meal per day, and (4) 1.0 lb. of soybean oil meal per day, fortified with phosphorus to be equivalent in phosphorus to 2 above. The soybean oil meal intake was controlled by mixing with salt. The treatments were from November until June on a desert shrub range of southwestern Utah. The most abundant plant species were rabbitbrush (Chrysothamnus stenophyllus), curly grass (Hilaria jamesii), shadscale (Atriplex confertifolia), Russian thistle (Salsola kali), and Indian ricegrass (Oryzopsis hymenoides). Seventy-two sections of land were divided into four pastures by electric fence and the treatment groups were rotated periodically to minimize pasture differences. Water was hauled to all groups. Soybean plus phosphorus resulted in significantly greater weight gains, November to June and November to October. The mid-February plasma inorganic phosphorus values were: 2.0, 2.9, 2.8, and 4.5 mg. P per 100 ml. plasma for control, phosphorus, soybean, and soybean plus phosphorus respectively, with the latter value being significantly different. The calves from the soybean plus phosphorus group were significantly heavier at birth, and the calves from both soybean groups made significantly greater summer gains which also resulted in their being significantly heavier at weaning.

107. WEIGHT GAINS OF BEEF CATTLE ON WINTER PASTURE AS AFFECTED BY ANIMAL WEIGHT, LEVEL AND FREQUENCY OF STILBESTROL IMPLANTS. D. M. Baird, O. E. Sell and W. E. Neville, Jr., *Georgia Experiment Station, Experiment*.

Five stilbestrol implantation tests were conducted with a total of 333 beef steers grazing winter temporary pastures (oats, ryegrass and crimson clover). The grazing periods averaged about 160 days in length with one period lasting 218 days. The starting weights ranged from 233–989 lb. with an average of 529 lb. Significant differences in weight gains between implanted and non-implanted animals occurred in 4 of the 5 tests. Average daily gains were: pasture only 1.88 lb. and implanted 2.17 lb. There were no significant differences in rate of gains between lots with initial implant levels of 24, 36 or 48 mg. Re-implanting near the latter third of the grazing period with 12 and 24 mg., giving a total of up to 60 mg., resulted in no significant differences in rate of gain when compared with lots receiving initial implants only. Implanting 12 mg. per mo. or 24 mg. each two months (to a total of 72 mg.) following initial implants of 24 and 36 mg. gave no significant differences in response when compared with single 24–48 mg. implants. For each 100 lb. difference in initial weight of the animals, there was an increase in average daily gain of .08 ($\pm$.07)** lb. This regression is based on pooled regressions within treatments since the within treatment regressions were not found to differ significantly. These tests indicate that levels of 24–36 mg. of implanted stilbestrol are as effective as higher levels for winter pastured cattle; and when the grazing period is not longer than 160 days, there is no advantage in re-implanting later in the grazing period.

108. THE VALUE OF STILBESTROL IMPLANTS FOR STEERS ON WINTER AND SUMMER PASTURE AND FOR STEERS IN DRY LOT FED A HIGH ROUGHAGE RATION. Garth L. Walker, Ed. F. Smith, B. A. Koch and R. F. Cox, *Kansas State College*.

One-hundred eighty-eight Hereford Steers were used in three experiments in a study of stilbestrol implants. In experiment I, 30 steer calves were wintered together on dry bluestem pasture. They were divided equally into three separate pens each

morning, and fed the following amounts of supplements per head daily; Lot 1, 1.0 lb. of soybean pellets; Lot 2, 2.0 lb. of soybean pellets; Lot 3, 1.0 lb. of soybean pellets and 1.0 lb. of ground corn. Six of the steers in each lot of 10 were implanted with 48 mg. stilbestrol. The daily gain per head for the controls and implants in each lot were as follows: Lot 1, .62, .68; Lot 2, .63, .99; Lot 3, .44, .79 lb. Experiment II consisted of 140 yearling steers on summer pasture. The steers were assigned to seven different pasture treatments. In each pasture half the steers were implanted with two levels of stilbestrol, 24 and 36 mg. In each pasture stilbestrol increased rate of gain, although in some cases it was not significant. The average daily gain per steer for all pastures during the 155 day period was as follows: Controls, 1.12; 24 mg. implants, 1.36; 36 mg. implant, 1.34. In experiment III, eighteen steer calves, eight of which were implanted with 36 mg. of stilbestrol, were wintered together in dry lot. They were fed 30 lb. sorghum silage, 3.9 lb. ground milo grain and one pound SBOM per head daily. Controls gained 1.59 lb. per head daily and the implants 2.02 lb.

109. EFFECT OF FEEDING ANIMAL GREASE TO LACTATING COWS GRAZING PASTURE OR EATING SILAGE. W. E. Thomas and R. D. Mochrie, *North Carolina State College.*

Sixteen lactating cows with corn or sart silage as the only forage were fed either a 17.5% protein simple concentrate or a 18.5% concentrate with 8% added yellow animal grease. The concentrates were fed at the rate of 1 lb. per 4 lb. of fat corrected milk (FCM) for a 12-week comparison period. Individual daily silage consumption data were recorded. When 20 lactating cows were turned to pasture after barn feeding one group was fed a 15% protein simple concentrate and the second group was fed a 15% protein concentrate with 8% added grease at the rate of 1 lb. per 5 lb. of FCM. Cows on the silage started with an initial FCM production of 37 lb. and 41 lb. and averaged 28 lb. and 33 lb. for the no grease and added grease rations respectively. Cows on the pasture trial produced an average of 30 and 32 lb. of FCM during that trial. Neither of these differences in FCM were significant when adjusted for initial production. The cows on silage lost 31 and 33 lb. of body weight when fed no-grease and added grease respectively for 12 weeks. The cows on pasture gained 27 and 25 lb. body weight when fed no-grease and added grease respectively for 6 weeks. The milk fat for the silage trial was 3.46% an 3.53%, and for the pasture trial 3.42% and 3.51% when no-grease or added grease was fed respectively. Palatability of the animal grease ration was no problem during the silage trial. Concentrate refusals on the pasture trial averaged .34 and .57 lb. per cow per day for no grease and added grease rations respectively.

110. FATTY ACID ACCUMULATION IN SHEEP RUMEN CONTENTS FOLLOWING FEED OF AN ALL-HAY RATION. A. J. Sheppard, R. M. Forbes and B. Connor Johnson, *University of Illinois.*

Rumen samples were taken at thirty minute intervals from two fistulated sheep fed an all clover hay diet and a mineral supplement free choice. The first sample was taken just before a 30 minute feeding period in the morning and the last sample before feeding in the evening. A partition chromatographic technique based on Celite 535 and a hexane-butanol solvent system was employed to separate and measure quantatively butyric, propionic, and acetic acids. A sharp rise in total acid production occurred during the first hour followed by a slower rate of increase up to at least four hours following feeding. No change in ratio of the acids was noted with time. The distribution was approximately 72% acetic, 21% propionic and 7% butyric acids.

111. THREE LACTATIONS OF FEEDING THYROXINE WITH IDENTICAL TWIN COWS. E. W. Swanson and W. M. Miller, *University of Tennessee.*

Five pairs of identical twin heifers have been used to compare normal feeding and management with feeding 100 to 140 mg. thyroxine daily from the 16th or 20th week

to the end of the lactation in each of the first 3 lactations. The peak weekly responses in milk production averaged 28.5, 16.4, and 27.1% in the 1st, 2d, and 3rd lactations, respectively. The average length of response was longest in the 1st lactation, 13 wk. compared to 10 wk. in the 2d and 3rd lactations. Both controls and treated twins increased in production as expected with age. The total lactation yields of FCM in consecutive years averaged 5813, 6856, and 7813 lb. for the controls and 6435, 6982, and 7877 lb. for the treated cows. Yields of FCM in the pretreatment periods by years averaged 3632, 4523, and 4900 lb. for the controls and 3709, 4533, and 4731 lb. for the treated. Two pairs in their 4th lactations also showed no carryover effect of thyroxine feeding. Only insignificant differences in body size and weight were noted in 4 pairs, but in the 5th pair the treated twin has been lighter than her mate since the 1st lactation. Average weights of four pairs at the beginning of the consecutive lactations were 680, 868, and 929 lb. for the controls and 678, 847, and 915 lb. for the treated twins. Those now in their 4th lactation show no noticeable differences in physical condition at maturity. These data indicate that thyroxine feeding in consecutive lactations has not had a harmful effect on the cows.

112. EFFECTS OF THYROTROPHIN, L-THYROXINE, AND L-TRIIODOTHYRONINE ON PLASMA PROTEIN-BOUND IODINE IN DAIRY BULL CALVES. J. P. Mixner and H. D. Lennon, Jr., *New Jersey Agricultural Experiment Station.*

The levels of plasma protein-bound iodine (PBI) were determined at varying time intervals after the intramuscular injection of thyrotrophin and the intravenous injection of sodium l-thyroxine pentahydrate and sodium l-triiodothyronine in Holstein bull calves (body wts. from 166 to 264 kg.). In four trials the amounts of thyrotrophin (Armour) injected were 10, 20, 40, and 80 USP units. The maximum increases in PBI above preinjection levels varied from 3.05 to 8.02 mcg. % at 15–31 hours post-injection. The biological half-life of the PBI during its return to normal ranged from 14.4 to 28.9 hours (mean of 22.2 hr.). L-thyroxine (2.5 and 5.0 mg.) and l-triiodothyronine (5.58 and 11.16 mg.) were injected in each of three trials. The declines of PBI in each instance were characterized by two first-order exponential regressions. The first represented the rate of movement of the materials into their respective distribution volumes (mean biological half-time, 1.93 hr. for l-thyroxine and 0.31 hrs. for l-triiodothyronine), while the second measured the rate of peripheral utilization or disposal of the materials (mean biological half-life, 17.9 and 5.10 hr. for l-thyroxine and l-triiodothyronine, respectively). The mean volumes of distribution for the l-thyroxine and l-triiodothyronine were 9.1 and 37.5% of body wt., respectively.

113. THYROID SECRETION RATES OF LACTATING AND NON-LACTATING DAIRY GOATS. E. E. Flamboe and E. P. Reineke, *Michigan State University.*

The technique for measuring individual thyroid secretion rates using I-131 and L-thyroxine injections (J. Animal Sci. 14:419, 1955) was applied to dairy goats. Maximal thyroidal I-131 uptake occurred at 3–7 days after injection. The comparatively rapid output rate of this species (t $\frac{1}{2}$=7.3±0.35 days) without thiouracil treatment permits rather precise determination of the amount of L-thyroxine needed daily to prevent I-131 output. This endpoint was used to measure thyroid secretion rate. The mean thyroid secretion of pregnant goats, including 2 aged and 3 two-year-old animals, during February was 0.262±0.008 mg. per 100 lb. body weight daily. A similar group of nonpregnant goats had a mean value of 0.277±0.05 mg. The mean thyroid secretion rates of a group of 4 aged and a group of 7 young lactating goats during May were, respectively, 0.188±0.007 and 0.263±0.010 mg. During July the

mean thyroid secretion rates of the aged and young groups were 0.05±0.010 mg. and 0.07±0.007 mg., respectively. The difference between the 2 age groups was statistically significant only during May. However, the seasonal decline in both groups was highly significant. Thyroid secretion rates of open non-lactating goats, including a group of 5 aged and a group of 4 two-year-old animals, were not appreciably different from those of lactating groups of similar age during May. In July, however, the thyroid secretion of non-lactating was higher than that of lactating goats.

114. EFFECT OF PROLONGED ADMINISTRATION OF THIOURACIL ON THE RELEASE OF RADIOACTIVE I^{131} IN THE THYROID OF FATTENING STEERS. Arthur Raun, Edmund Cheng and Wise Burroughs, *Iowa tSate College.*

Eight individually-fed yearling beef steers on full feed were used to study the effect of orally administered thiouracil on the net release of radioactive iodine (I^{131}) from the thyroid gland. The experiment was divided into four different six-week periods; the first being a control period during which none of the animals received thiouracil, while in the subsequent three periods, three groups of two animals were placed on oral thiouracil treatments with the two remaining animals serving as controls. The levels of thiouracil used were 1, 3, and 5 gm. per day during the second period, 5, 7, and 9 gm. per day during the third period and 11, 14, and 20 gm. per day during the final period. The animals were injected intravenously with 150 microcuries of carrier-free radioactive iodine (NaI^{131}) at the initiation of each period. The activity in the region of the thyroid was determined periodically throughout the first four weeks of each period using a G-M tube in conjunction with a scaler. The results indicated that the net rate of release of radioactive iodine from the thyroid was not affected by the levels of thiouracil studied, with one possible exception in which this rate was slightly increased in an animal receiving 20 gm. of thiouracil per day. Rate of gain, feed efficiency and feed consumption were depressed by the 14 and 20 gm. thiouracil treatments, while the 1 through 11 gram levels had no effect.

115. EFFECT OF CONSTANT ENVIRONMENTAL TEMPERATURE (50 AND 80° F.) ON THYROID I^{131} ACTIVITY OF HOLSTEIN, BROWN SWISS, AND JERSEY CALVES DURING GROWTH. H. D. Johnson and C. S. Cheng, *University of Missouri.*

In studies on the influence of environmental temperatures on thyroid activity of dairy calves it was observed that from one month to approximately one year of age, there was a gradual increase in thyroid I^{131} release rate; a striking increase in most individuals up to 3 months with a more gradual change theerafter. At 50 and 80° F. constant environmental temperature the Jersey calves maintained the highest thyroid activity. In the 80° F. group the thyroid activity was significantly lower in the Brown Swiss and Holstein calves. However, at 80° F. the thyroid activity of the Brown Swiss calves was similar to the Jerseys. These *in vivo* measurements were determined from one month to approximately one year of age. The average K values obtained for this period are as follows: 7.38×10^{-2}, 5.1×10^{-2}, and 5.3×10^{-2} for the 50° F. Jersey, Brown Swiss and Holstein respectively; and 6.72×10^{-2}, 6.3×10^{-2}, and 4.48×10^{-2}, respectively for the three breeds at 80° F. The Jersey and Holstein values reflect the depressive effect of the 80° F. tmperature, whereas the Brown Swiss values do not. The percentage increases in thyroid activity per 100 kg. increase in body weight are as follows: 19.7% increase in the 50° F. Brown Swiss compared to 28.2% at 80° F., and 8% increase in 50° F. Holstein and 14.6% for the 80° F. Holsteins; and a 25.7% increase in the 50° F. Jersey as compared to 30% increase for the 80° F. Jerseys. (Supported by A.E.C.) Mo. Agr. Sta. Journal Series No. 1785 Approved by Director.

116. THE INTERRELATIONSHIPS OF THYROID FUNCTION, AMBIENT TEMPERATURE, AND THE VITAMIN A REQUIREMENT OF THE YOUNG PIG. D. L. Frape, V. C. Speer, V. W. Hays and D. V. Catron, *Iowa State College.*

Three experiments involving 120 pigs weaned at 7 days are described. The first was designed to study the interaction of ambient temperature (45° and 65°) with vitamin A status measured by weight gains, feed efficiency, plasma and liver vitamin A, spinal fluid pressure and rate of thyroxine secretion in the young pig. Weight gains plateaued between 400 and 1600 IU vitamin A per lb. of feed with a highly significant quadratic regression and significant quadratic interaction of a higher requirement occurring in the higher temperature. The adequacy of 400 IU was maintained up to the termination of the experiment, at 14 weeks of age. The state of spinal pressure, plasma and liver vitamin A were almost identical under the two temperatures, with normality, as previously reported occurring in all cases between 400 and 1600 IU. Thyroid secretion rate was measured using I^{131} and reabsorption being blocked with thiouracil. The thyroid secretion rate constants showed a significant quadratic regression on vitamin A level, and indications of a relationship with feed efficiency. Pigs, all fed diets containing 3000 IU of vitamin A per lb. showed correlations of secretion rate with gain of +.292, −.514 and +.383 accompanied by percentage rate constants of secretion (per day) of 28.4, 47.6 and 32.1 respectively at 1.8, 7.5 and 13 weeks of age. Although the plot of log corrected thyroid activity against days is approximately linear in these pigs it was shown more exactly to be a highly significant curved relationship with, in the case of the 7 week old pigs, the best fitting least squares curve being $\log Y = 4.040 + .0194X - .0334X^2$.

117. THE THYROXINE SECRETION RATE OF DAIRY CALVES ESTIMATED BY THE EXTRAPOLATION TECHNIQUE. R. C. Lewis, J. R. Lodge and E. P. Reineke, *Michigan State University.*

Each calf was injected with a tracer dose of I^{131}. On the sixth to the twelfth day after administration of the isotope, oral treatment of 0.2 gm. of thiouracil per kg. of body weight daily was started and continued for the duration of the trial. After four days of thiouracil treatment, daily injections of L-thyroxine were initiated. The level was increased by 0.1 mg. every second day and a thyroid count obtained on each dosage level prior to injection of the increased dose. The daily thyroxine secretion rate was estimated by plotting the corrected thyroid count, computed as percent of the previous count, against the L-thyroxine dosage level. The point at which the line crossed 100% was taken as the thyroxine secretion rate for that animal. The average daily thyroxine secretion rate of 42 calves was 0.57 mg. per 100 lb. of body weight with a range of 0.36 to 0.84 mg. Although the Brown Swiss calves had a slightly lower average secretion rate than calves of the other breeds, there was more variation between individuals within a breed than between breeds. A large seasonal difference in secretion rate, which has been found in other species of animals, was not demonstrated in this study. A slight difference in rate was noted between studies in May and August in 1955 with the latter being generally lower. However, in the following year, with trials conducted during the same months, this difference was not observed.

118. A STUDY OF THYROXINE SECRETION IN CATTLE. B. N. Premachandra, G. W. Pipes and C. W. Turner, *University of Missouri.*

Using the radioiodine technique (J. Dairy Sci. 40:340, 1957) thyroxine secretion rates were determined in cows and calves individually during various months of the year. A total of 96 estimations, (60 in cows and 36 in calves) revealed that the thyroxine secretion rates were high in winter (December-April) and low in summer months (May-September). During the winter season the thyroxine secretion rates

varied between individuals by as much as 0.2–0.7 mg. of L-thyroxine per 100 lb. body weight with an average of 0.5 mg. per 100 lb. body weight while in summer the range was 0.1–0.3 mg. L-thyroxine per 100 lb. body weight with an average of 0.17 mg. per 100 lb. body weight. A three fold individual variation in thyroxine secretion rates was observed in both summer and winter months. The thyroxine secretion rate was depressed in summer to about 30% of the winter value. A knowledge of the effect of temperature on thyroxine secretion rates will help to make adequate corrections when estimations are made during various times of the year. If the relative thyroxine secretion rates of calves predict their secretion at maturity, than a calf showing a low thyronixe secretion rate could be safely culled from the dairy herd. It will be interesting to note the reaction of cattle to high summer temperatures as related to heat tolerance. Journal Series No. 1772, Approved by the Director.

119. BIOLOGICAL ASSAY OF STEER CARCASSES FOR GOITROGENIC ACTIVITY FOLLOWING THE FEEDING OF METHYL-THIOURACIL IN THE FATTENING RATION. Charles W. Turner, *University of Missouri.*

Interest is increasing in the possible use of goitrogens (thiouracil and methyl-thiourocil) in the fattening of cattle. It has been shown in our laboratory that the feeding of 1 gm. per 100 lb. body weight of these compounds will completely block thyroxine secretion in cattle. Before these compounds can be incorporated in cattle rations, it is necessary to determine whether the tissues of cattle so fed would contain detectible amounts of the goitrogen in the edible tissues. Data will be presented on the bioassay of tissues of steers fed methyl-thiouracil at the rate of 0.5 gm. per 100 lb. body weight in comparison with a similar group of control steers. The following tissues were compared: rib-eye, liver, kidney, digestive tract and depot fat. Young female mice were fed exclusively on the meat samples for 10 days, then killed and the thyroid glands dissected out and weighed. In comparing individual tissues, it was noted that the control and goitrogen-fed tissues in two cases, namely liver and kidney, produced essentially similar responses, whereas the ribeye, digestive tract and depot fat were slightly higher in mean thyroid weight in the experimental groups. It was concluded from these assays that under the conditions of the present trial, the amount of residual methyl-thiouracil in the tissues of beef cattle fattened with this goitrogen is negligible. Journal Series No. 1771. Approved by the Director.

120. FACTORS AFFECTING PROLIFICACY IN A FARM FLOCK. J. W. Oxley and P. O. Stratton, *University of Wyoming.*

Two- to eight-year lambing records of 663 farm-flock ewes involving 3270 births were analyzed. The effects of lambing or not lambing the first year of life and the type of birth of ewe on subsequent lamb production were measured by the average number of lambs born per number of opportunity years (ewe years). Those ewes lambing versus those not lambing as lambs averaged 1.35 and 1.06 lambs per ewe year, respectively. This was a 27% lifetime advantage in production of ewes lambing as lambs over an average of four years of complete lambing records. Those ewes giving birth to lambs their first year of life were slightly older than those not lambing until two-year-olds; however, this difference was not significant at the 5% probability level. There was no significant difference in average number of lambs per ewe year between ewes born as twins or as singles as determined by the contingency table method of non-parametric analysis and the chi-square test.

121. A STUDY OF THE REPRODUCTIVE PERFORMANCE OF A PURE-BRED HEREFORD HERD. C. E. Lindley, J. A. Whatley, Jr., G. T. Easley and Doyle Chambers, *Oklahoma A. & M. College.*

The records of the Turner Hereford Ranch Herd, Sulphur, Oklahoma involving 848 cows and 3,606 gestations over a 17-year period were used for this study. The average reproductive performance for this period was: number of services per

conception, 1.7; interval from calving to conception, 108.2 days; gestation length, 285.7 days, calving interval, 394.2 days; interval from calving to first breeding, 75.5 days; and interval from first breeding to conception, 31.0 days. In general, the reproductive performance was higher in summer and fall than in spring and winter. All correlations and regressions of reproductive performance on age of cow were positive and significant. The rapid decline at the older ages caused the regression to be curvilinear. During the period of this study 530 cows were taken from the herd at an average age of 7.8 years. Cows that were sent to market at the end of their productive life had an average age of 9.2 years. Thus they had a productive life of 7.5 years. Cows bred more than 60 days post partum required fewer services per conception than those bred prior to 60 days post partum. Heritability and repeatability estimates for the different reproductive traits were generally low. The repeatability estimates varied from 0.03 to 0.15. The heritability estimates were near zero from the paternal half-sib estimates and somewhat larger from correlation of daughter and dam records and regression of daughter on dam records. Of the cows 3.2% failed to produce a calf from an average of 8.8 services and were sold as barren.

122. THE RELATIONSHIP OF ALTERED THYROID ACTIVITY TO VARIOUS REPRODUCTIVE PHENOMENA IN GILTS, WITH SPECIAL EMPHASIS UPON EMBRYONIC MORTALITY. Stewart H. Fowler and George E. Brunstad, *State College of Washington.*

Thirty Palouse gilts were randomly assigned into three treatment lots at first estrus. The 10 gilts in each lot were fed an adequate basal ration, with Lot I receiving 0.15% thiouracil in the ration, Lot II receiving 112 grams of thyroprotein per ton of feed, and Lot III serving as the control. All gilts were given two services by a "normal" boar at third estrus and were maintained on their respective treatments until 38 days after breeding. At that time, all gilts were slaughtered, and data were collected on ovulation rate and on embryo survival. Control gilts ovulated an average of 14.6 ova as compared with 13.9 and 13.0 for gilts receiving thiouracil and thyroprotein, respectively. It appears that thyroprotein tended to reduce ovulation rate, but the differences in ovulation rates were not statistically significant. Control gilts had a mean of 9.3 normal embryos, as compared to 8.7 and 7.0 for thyroprotein- and thiouracil-supplemented gilts, respectively. This represented an embryonic loss of 4.3 embryos per gilt for thyroprotein-supplemented gilts, 5.3 for control gilts, and 6.9 for thiouracil-supplemented gilts. Thus, gilts receiving thyroprotein exhibited the lowest embryonic mortality (31.1% as compared to 36.3% and 49.6% for control and thiouracil-treated gilts, respectively). The differences for embryonic mortality were not statistically significant. Although thyroprotein-fed gilts exhibited the lowest embryonic mortality, control gilts had a slight advantage (0.6 embryo) for number of normally developing embryos. This may be explained, however, by the higher ovulation rate (1.6 ova) exhibited by the control gilts.

123. RELATIONSHIPS OF MEASUREMENTS AT 154 DAYS WITH CARCASS MERIT ON SWINE SLAUGHTERED AT 205 TO 225 POUNDS. O. W. Robison, J. H. Cooksey, A. B. Chapman and H. L. Self, *University of Wissin.*

The basic problem under study here was to evaluate data taken on swine at 154 days of age in terms of their predictability of carcass merit at slaughter weight. Measurements of depth at shoulder, width at shoulder, backfat at shoulder and loin, length of foreleg and weight were taken on 282 pigs at 154 days of age in 1955. Similar measurements at the same time were taken in 1956 (measurements of depth at shoulder were omitted and width at loin and circumference of shin, foreleg and

belly were added). Use of these measurements to predict carcass traits in these animals when slaughtered at about 210 lb. live weight resulted in multiple correlations (within sex and breeding groups) of .54, .38, .54 and .53 when percent lean cuts, loin eye area, average carcass backfat and length of carcass were the respective dependent variables. The corresponding values for 1956 were .70, .37, .66 and .59. The combination of two independent variables which gave the highest multiple correlations in 1955 were backfat at loin with 154 day weight or length of foreleg. Their respective multiple correlations with percent lean cuts were .47 and .48. In 1956 the best two combinations were 154 day weight with backfat at shoulder or backfat at loin. They gave multiple correlation coefficients with percent lean cuts of .52 and .43, respectively. These values are phenotypic; heritabilities, genetic correlations and economic values are being calculated in order to use these traits in a selection index.

124. HERITABILITY OF CARCASS LENGTH, CARCASS BACKFAT THICKNESS AND LOIN LEAN AREA IN SWINE. J. A. Whatley, Jr. and Frank D. Enfield, *Oklahoma State University*.

Five hundred thirty-one carcasses from the swine breeding project at the Oklahoma Experiment Station were used in the study. These carcasses were from 304 pigs at the Stillwater station and 227 from the Fort Reno station. The data were collected over a four year period with a total of twelve pig crops represented in the study from the two stations. Heritability estimates obtained from the analysis of variance using the paternal half-sib correlation were as follows: carcass length, .50; backfat thickness, .42; and loin lean area, .79. A much higher estimate of .84 was obtained for backfat thickness using the maternal half-sib correlation. This may be attributed either to sampling error or a large maternal influence on the trait. There was no indication of a possible maternal influence on either carcass length or backfat thickness. Phenotypic correlation were calculated on an intra-season-station basis thus removing the effects any time trends or changes in management would have on the results. A highly significant correlation of —.36 was found between backfat thickness and carcass length. Backfat thickness was also significantly correlated with loin lean area with a correlation of —.27. The positive correlation of .10 between carcass length and loin lean area was not statistically significant.

125. DIFFERENCES IN LITTER SIZE AND GROWTH RATE AMONG PUREBRED AND CROSSBRED SWINE. J. A. Gaines and L. N. Hazel, *Iowa State College*.

Characteristics studied were litter size at birth, 56 and 154 days, and average weight per pig at 56 and 154 days. Litter size was larger at Ankeny; growth rate was superior at Napier; seasonal influences had marked effects; age of dam influenced all characteristics. First step was to correct for season, farm and age of dam by fitting constants. Landrace-Poland pigs were superior in growth rate to pigs of the two pure breeds; Poland boars on Landrace sows were far superior to Landrace boars on Poland sows (595 litters). Crossbred sows were superior to purebred sows in litter size at all ages; PxL sows were superior to crossbreds of later generations of crossing with Duroc, CW, and Hamp. breeding (1360 litters). Comparison of LxP with PxL sows failed to show any difference in inherited maternal effect (466 litters). Nine inbred lines of Poland boars topcrossed on Landrace sows showed significant differences for 154-day weight and litter size at birth and ranked approximately the same as in earlier matings on Poland sows (83 litters). Using a fourth breed on DPL sows gave better results than using one of the two original breeds when the fourth breed was Yorkshire, Hampshire or Montana No. 1 and poorer results when fourth breed was CW (246 litters). Comparison of CW and

Duroc boars when crossed on PxL sows showed Durocs to be superior at 56 and 154 days (276 litters). It appears possible to attain high production and maintain it by a rotational crossbreeding system using boars of several breeds on succeeding generations of crossbred sows.

126. A COMPARISON OF FIVE METHODS OF ESTIMATING CLEAN FLEECE WEIGHT. George M. Sidwell, P. E. Neale and Gordon L. Jessup, Jr. *USDA and New Mexico Agricultural Experiment Station.*

Clean fleece weight obtained by scouring the whole fleece from a total of 139 yearling ewes and 61 yearling rams was compared to (1) the results obtained from scouring small side samples, (2) multiple regression equations predicting clean fleece weight from wool density, body weight, staple length and grease fleece weight, (3) a method described by Neale and McFadden in New Mexico Agr. Exp. Sta. Press Bul. No. 1131 and (4) the results obtained from a new machine designed by P. E. Neale for estimating clean fleece weight. All methods of estimation appear to be reasonably accurate as shown by the correlation coefficients between whole fleece scouring and each of the four methods described above. These correlations were .92, .95, .87, and .87, respectively. It was shown by the multiple correlation coefficients that very little information concerning clean fleece weight is lost in predicting clean fleece weight by the multiple regression method if wool density and body weight were omitted from these equations. The small increase in accuracy of the small sample and multiple regression methods over the machine method does not compensate for the saving of time and expense involved as the machine method requires less than two minutes per fleece for the estimate. The machine requires no technical skill or knowledge for its operation and is applicable to all flocks. Also, the clean fleece weight estimate derived from the machine is independent of all other traits.

127. RELATIONSHIPS OF STAPLE LENGTH OF GREASE WOOL AND FIBER LENGTH OF TOP OF MAIN SORTS OF INDIVIDUAL FLEECES TO OTHER TRAITS OF TARGHEE SHEEP. Mary E. Hourihan, Russell L. Clark, Francis E. White, and Clair E. Terrill, *USDA, A. R. S., Animal Husbandry Research Division, Dubois, Idaho and Beltsville, Maryland, in cooperation with the Idaho Agricultural Experiment Station.*

Staple and fiber lengths of top and their respective variabilities were studied on main matchings of yearling Targhee fleeces from 117 ewes sheared in 1950 and 211 ewes sheared in 1951. In addition, staple lengths and variabilities were studied from 232 ewes sheared in 1952. Correlations were obtained with other traits of these fleeces which had been studied previously. Top was produced by combing each fleece on a French comb with constant settings for medium wool. Fiber length of top was considerably shorter (about one inch and more variable than staple length with coefficients of variation of about 46% for top and 11% for staple length. Correlations of staple length with top fiber length were moderately low (.33 and .34) but highly significant. Fiber length of top was positively and significantly correlated with top yield (.53), matching yield (.37), clean fleece weight (.25), fineness or grade (.18 to .35) and weanling index of overall merit (.19), but negatively and significantly correlated with noil yield (—.52). Higher correlations were generally found for staple and fiber length with visual grades than with fiber diameter or grade determined from fiber diameter. Unstretched and stretched staple lengths were closely related and both showed high correlation (.77 and .76) with staple length measured at the midside before shearing. All three staple length measurements showed similar relationships to other traits indicating that stretched staple length is unnecessary. In fact, staple length at the midside, based on three independent measures, appears to be as satisfactory as length based on measuring 50 locks.

128. SLOPE, OR ANGLE, OF INCLINATION OF THE RUMP IN DAIRY CATTLE AS INFLUENCED BY AGE. H. P. Davis and I. L. Hathaway, *University of Nebraska.*

The slope of the rump is a matter of concern among breeders and exhibitors of dairy cattle. A long level rump with the pinbones level, or nearly level, with the hooks (hips) is ideal. That condition seldom exists, since the pinbones are often distinctly lower causing a slope which may be measured in minus degrees. The data discussed were based upon monthly measurements, beginning at birth and continuing for so long as the animal remained in the herd. The instrument used was a bovine clinometer or large scale protractor. The numbers of animals measured, and the number of sires represented were as follows: for females; Holstein 218—(25 sires); Ayrshire 95 (10 sires); Guernsey 68—(8 sires); Jersey 125—(16 sires). For males the figures were: Holstein 158—(25 sires); Ayrshire 49—(9 sires); Guernsey 16—(9 sires); and Jersey 59—(9 sires). In all cases the pinbones were lower than the hooks (hips). There was a decline from the initial angles to a low point which occurred between the second and seventh month, depending upon breed and sex. From the low point there was a rump angle measurement rise which for Holstein and Ayrshire females continued with some variations through sixty months of age. Guernsey and Jersey females showed lower rump angle increases. Males of all breeds showed greater rump slope at birth and declined to a low point between the fifth and seventh month, followed by a rise.

129. THE INTERRELATIONSHIP AMONG AGE, BODY WEIGHT AND MILK PRODUCTION OF HOLSTEIN-FRIESIAN COWS IN LOUISIANA. Cecil Branton and E. J. Stone, *Dairy Department, Louisiana State University.*

It has been observed that the current Holstein age correction factors do not adjust the milk production records accurately for the younger cows in Louisiana and that these cows are smaller in size than the cows in the temperate regions. Since these factors have an important bearing on the selection of breeding animals, studies of the interrelationship between age, body weight and milk production in the L.S.U. Holstein herd were undertaken. A total of 1772 records of age and milk production (2X—305 day actual) were available on 407 cows. Both multiplicative and "lumped" age correction factors are being derived from these data. Data on age, body weight and milk production were available on 143 of these cows. It has been found that the current Holstein breed age correction factors under convert milk production records on cows from 2 to 6 years of age and correct accurately records of older cows in this herd. For example, the current breed factor for a 3-year old is 1.18 as compared with a factor of 1.25 in this herd. The average body weights of 143 of these cows at 27, 36, 48, 60 and 72 to 84 months of age were 909, 1035, 1095, 1168 and 1213 lb., respectively. Through the use of partial correlation analyses it was found that the level of milk production was much more highly correlated with body weight than with the age of these cows.

130. AN INTRA-HERD CONTEMPORARY COMPARISON OF THE PRODUCTION OF ARTIFICIALLY AND NATURALLY SIRED DAIRY COWS IN GEORGIA. E. W. Hahn, J. L. Carmon and W. J. Miller, *University of Georgia.*

The purpose of the study was to determine the amount of genetic improvement which resulted from the artificial breeding program as compared to the natural breeding program in Georgia. Milk and fat production and fat percentage data from 715 Holstein, Guernsey and Jersey first lactation records, which were made between 1951 and 1956, were investigated using contemporary comparisons. There were no significant milk or fat production differences between artificially and naturally sired progeny. The fat test of the artificially sired Holsteins was 0.16% higher than their mates. This was the only difference which was significant. There was no evidence to indicate that

either the sires used in artificial or natural breeding exerted a greater genetic influence at different herd production levels. No specific trends were evident for the effect of month of calving on milk or fat production for any breed. Between herd differences was the largest source of variation between records, averaging 30% for the three breeds. While non-significant, for any breed, about 20% of the total variation between records was due to differences between months. Approximately 6 to 8% of the total variation between records was due to differences between years.

131. RELATIONSHIP OF ROUGHAGE CONSUMPTION TO BODY SIZE AND ITS REPEATABILITY IN DAIRY HEIFERS. A. A. Rimm, R. E. Mather and J. W. Bartlett, *New Jersey Agricultural Experiment Station.*

Repeatability of roughage consumption measurements, as preliminary to heritability estimates, was determined with 24 Holstein and 9 Guernsey heifers, divided evenly into three groups. Consumption was measured for two consecutive 5-day periods following a 4-day adjustment (three groups in succession). Two subsequent trials or cycles were run at intervals of 6 weeks (total 30 days per animal). Hay and silage were relatively uniform in the first two cycles; hay was changed for the third cycle. Hay was fed ad libitum, plus 1.5 lb. grain and 16 lb. silage per day. Animals were measured in each 5-day period. Average body weight was 969 lb. and average dry matter consumption was 18.0 lb. per day. Average between-animal within-cycle correlations between dry matter consumption and body measurements were: body weight 0.873, hip width 0.840, heart girth 0.830, chest depth 0.817, wither height 0.812, paunch girth 0.804, and body length 0.777. Correlation with the combination of skeletal measurements, length x width x depth was 0.842. All correlations were highly significant. Average regression of daily dry matter consumption on body weight (100 lb.) was 1.31 lb. Differences in consumption among animals (adjusted for body weight) were highly significant. The repeatability of consumption was 0.32. The change of hay in the third cycle did not alter the relative consumption of the animals. Seven Holstein sires had two or more daughters each; 9.3% of the variances among these 20 animals was attributable to sire differences (consumption adjusted for body weight).

132. CYTOLOGICAL OBSERVATIONS ON SPERMATOGENESIS IN THE BULL. N. S. Fechheimer and L. O. Gilmore, *The Ohio State University.*

Testicular material from 14 bulls under 15 months of age was used to study the structure and quantitative variation of bovine chromosomes. All of the five major dairy breeds were represented. Observations were made from Feulgen stained squash preparations. The chromosome numbers were determined in 52 cells during various phases of mitosis and meiosis. The number most characteristic of spermatogonia was 60 and that of meiotic cells was 30. Deviations from these numbers as great as ± 5 for spermatogina and ± 2 for meiotic cells were observed. There were no primary or secondary constrictions visible in any of the chromosomes. All chromosomes take the shape of rods rather than V or J. From these observations it was inferred that the kinetochores of all chromosomes were terminal. At diakinesis, most bivalents have the appearance of a bird in flight; this is evidence that a minimum of two chiasmata are present in each pair. Another striking feature of diakinesis is the appearance of one unequal pair, presumably the X-Y pair. The X is approximately twice the length of the Y and synapsis between the two takes place along the greater part of the Y. The observations herein described will be shown with slides.

133. HERITABILITIES, GENE INTERACTIONS AND CORRELATIONS FOR GROWTH OF TISSUE ASSOCIATED WITH ANTIBODY FORMATION IN THE VERY YOUNG CHICK. R. George Jaap, *Ohio Agricultural Experiment Station.*

Chang (1957-Ph.D. dissertation, Ohio State University) has demonstrated that the bursa of Fabricius, a lymphatic gland, is vital for antibody production during the

first two weeks after hatching of the chick. By ten weeks of age the spleen has assumed this function. Both spleen and bursa weights are correlated with body weight, being .49 and .47 at hatching, and .54 and .79 respectively at 11 days of age. When the effect of body weight is removed from the 11 day data, the genetic correlation between spleen and bursa weight is .30 while the environmental correlation is —.28. Regression of gland in mg on body weight in gm at hatching is .40 for spleen and 1.43 for bursa. At 11 days after hatching, these regressions change to 1.41 and 4.88 for spleen and bursa, respectively. Gross heritability from the components of inter- and intra-family variance at a constant body weight, as estimated from 253 families, at hatching were .89 for spleen and .92 for bursa. Similar gross heritabilities at 11 days of age, as estimated from 268 families, were .56 for spleen and .76 for bursa. Gene interactions were estimated from the pooled variance of 21 sets of diallel matings at hatching and from 29 sets at 11 days of age. Only additive genetic effects were detected for spleen weight at hatching. Non-additive genetic effects accounted for approximately half of the genetic variance for bursa weight at both ages and approximately 40% of the genetic variance for spleen weight at 11 days of age. Some evidence of sex-linked gene effects on the bursa (S=.17 versus D=.07) at 11 days after hatching.

134. VARIATIONS IN SERUM PROTEIN-BOUND IODINE LEVELS IN IMMATURE BEEF CATTLE. George G. Green, David K. Stokes, Jr., Carl M. Lyman and H. O. Kunkel, *Texas Agricultural Experiment Station.*

Two methods of determination of the serum protein-bound iodine have been used in this laboratory, the alkaline ash method of Brown, Reingold, and Samson (*J. Clin. Endocrin.* 13:444, 1953) and the chromic acid oxidation and distillation method of Moran (*Anal. Chem.,* 24:378, 1952). The reduction of ceric ions in the alkaline ash method was found to be accelerated or inhibited by otherwise undetectable contaminants in the system and hence less reliable than the distillation method. Repeatability of determinations on the same sample of serum ranged from 0.55 to 0.72 with the alkaline ash method, but was on the order of 0.91 with the distillation method. Repeatabilities on successive samples taken from the same animal 4 to 5 months apart have ranged from 0.50 to 0.69, the latter estimate of repeatability obtained with the distillation method. Significant individual differences, therefore, exist during the feeding period. Estimates of heritability of differences in PBI have been calculated from half-sib correlations, but have been higher than the estimates of repeatability, suggesting the expression of effects of similar pretest environmental conditions of those calves within each sire group persisting throughout the feeding period and different pretest conditions of groups of calves from different breeders. Occasional statistically significant correlations have been noted between PBI and serum globulin, blood glutathione, or hemoglobin level.

135. PROCESSING AND ORGANOLEPTIC CHARACTERISTICS OF HAMS FROM U. S. MEDIUM, U. S. NO. 1 AND U. S. NO. 2 GRADE PORK CARCASSES. E. Birmingham, H. D. Naumann, D. E. Brady, V. J. Rhodes, E. R. Kiehl and R. H. Cook, *University of Missouri.*

Current consumer demand for lean pork has stimulated a need for information on the processing and organoleptic characteristics of pork cuts from lean type carcasses. One hundred fifty-six hams from U.S. Medium, U.S. No. 1 and U.S. No. 2 grade pork carcasses were procured from a major midwest meat packer. Data were obtained on the curing, smoking and storage yields as influenced by grade. Sensory evaluations were obtained by a six member laboratory panel and a 60-family household consumer panel. Preliminary data indicate that grade exerted no influence on the processing yields. Laboratory taste panel data indicate a preference for the hams from the U.S. Medium grade pork carcasses.

136. THE EFFECT OF DIFFERENT DEGREES OF PORK CARCASS FATNESS ON SOME PROCESSING AND PALATABILITY CHARACTERISTICS. R. L. Saffle and L. J. Bratzler, *Michigan State University*.

Sixty-nine pork carcasses were divided into three groups according to the average fatback thickness as follows: 23 carcasses—1.0 to 1.3, 21 carcasses—1.3 to 1.6 in., and 25 carcasses—1.6 to 1.9 in. Taste panels consisting of 12 members and using the Hedonic scale were utilized to test palatability of center cut pork chops, semimembranosus muscle of cured hams, and bacon slices taken at the last rib. Hams were cured by artery injection and bacons were dry cured. The amount of drip from thawing the frozen Boston butt, center loin section, and loin chops from the blade end was determined after defrosting for 48 hours. Analysis of variance revealed highly significant differences in palatability of the pork chops, with chops from the highest finished carcasses having the highest score followed by intermediate and the least finished carcasses. No significant differences in palatability were noted for the hams or bacons. Differences in curing losses of the bellies were highly significant. Loss during curing decreased as fatness increased. Carcass fatness had no effect on ham curing yields. Differences in defrosting drip were highly significant for chops but not for the Boston butts nor center loin roasts. Drip loss decreased as carcass fatness increased.

137. AN EVALUATION OF METHODS OF IMPROVING CARCASS FIRMNESS OF PIGS GROWN ON PEANUTS. A. A. Straughn, A. Z. Palmer, R. H. Alsmeyer and H. D. Wallace, *Florida Agricultural Experiment Station*.

Forty-one pigs were used in two trials to study the effectiveness of four methods of improving carcass firmness of pigs grown on peanuts. In the first trial, 16 pigs were fed individually to compare the hardening effects of a corn-soybean oil meal ration with a ration containing 22% saponified beef tallow and 18% protein. Differences between treatments in average daily gain, manual firmness of carcasses and refractive indices of both back and leaf fats were highly significant. Both the corn and the tallow hardening rations improved carcass firmness, although some question remains as to whether or not the effects were of practical magnitude. In the second trial, 25 pigs were fed in six treatments. The hardening effect of a ration containing 15% acidulated coconut oil soapstock and 18% protein and fed immediately following growth on peanuts was compared to a treatment using the same diet but fed after the pigs had been allowed only a maintenance diet for ten days following growth on peanuts. Differences between treatments in manual firmness of carcasses and refractive indices of back and leaf fats were highly significant, although it was apparent that the limited feeding treatment did not contribute to the hardening effect. Finishing with 70 lb. of gain on hardening ration improved carcass firmness appreciably; finishing with smaller gains gave less improvement, although it was easily detected. Neither dressing percent nor back fat thickness was influenced by treatments of either trial.

138. STABILIZATION OF HOG CARCASS FATS BY ADDITION OF ANTIOXIDANTS TO THE RATION. G. P. Lynch, W. R. Lewis and G. C. Anderson, *West Virginia University*.

A study was initiated to determine the effects of butylated hydroxytoluene (BHT) and N, N'-diphenyl-p-phenylenediamine (DPPD), as ration constituents, on the stability of hog carcass fats. Five groups of hogs were used with five individuals per group. Each antioxidant was fed at levels of 0.025% and 0.1%. The hogs were self-fed for thirty days. Tissue samples were taken from the belly area of each hog after slaughter and frozen for subsequent rendering and fat stability determinations. Samples were assumed to be rancid when a peroxide value of 20 was reached. No significant differences between groups in rates of gains or feed efficiency was found. BHT sig-

nificantly (P=0.05) prolonged the induction period of the carcass fats at both levels. DPPD was markedly effective (P=0.01) at the 0.1% level and significantly (P=0.05) prolonged the induction period of the carcass fats at the 0.025% level. The average number of hours required to attain a peroxide value of 20 for each group appears as follows: Control 16.6, 0.025% BHT 21.6, 0.025% DPPD 29.7, 0.1% BHT 25.1 and 0.1% DPPD 47.5 hours.

139. THE EFFECT OF SMOKING AND SMOKING TEMPERATURES ON THE SHRINKAGE AND QUALITY OF DRY-CURED HAMS. James D. Kemp, William G. Moody and W. Y. Varney, *University of Kentucky*.

Ninety hams were dry-cured for 21 days at 36–40° F. They were randomly assigned to 5 groups of 18 hams each. Group 1 was not smoked, whereas groups 2, 3, 4, and 5 were smoked to internal temperatures of 95, 110, 125, and 140° F., respectively. They were aged for 6 months at 65° F. with a relative humidity of 55%. Shrinkage was determined at regular intervals during processing and aging. Fat characteristics were determined during processing and aging by iodine numbers, peroxide numbers and free fatty acid content. Palatability tests were conducted on lean center slices after aging. Shrinkage increased throughout the processing and aging period ($P<0.01$). Iodine numbers increased through curing but decreased during aging ($P<0.01$). Unsmoked hams had higher iodine numbers than smoked hams ($P<0.01$). Peroxide numbers decreased as smoking temperatures increased but increased with aging. Free fatty acids increased with each period of aging, ($P<0.05$), but their development was retarded by higher smoking temperatures. Hams smoked at 125° F. or above showed slight to severe deterioration after aging and the cut surface was usually pink. Those smoked at 110° F. or below or not smoked were sound and the cut surfaces were red. There was little difference in taste among the groups; however, tenderness increased as smoking temperature increased ($P<0.01$).

140. THE DEFATTED HAM AS AN INDICATOR OF HOG CARCASS VALUE. Charles Smith, Ralph M. Durham, A. W. Munson, E. L. Lasley and E. A. Kline, *Iowa State College*.

A more accurate indicator of hog carcass value than the percent of lean cuts currently used, might incorporate the relative market value of the four cuts—ham, loin, picnic and Boston-butt—in addition to their weights. The ham comprises approximately 1/3 of the total lean cuts, has the highest repeatability between sides, and the highest value per pound of any of these four cuts. Hence some function of the ham weight might provide the most suitable single basis for estimating the percent of lean cuts and carcass value. Especially promising is the weight of lean in the ham, expressed as the percent which the defatted ham is of the chilled carcass weight. The relationship was investigated in data on 300 barrows from the Iowa Swine Testing Association. These barrows represented 9 breeds and 3 seasons. The correlation between defatted ham percent and lean cuts percent is partly automatic, since the ham comprises 1/3 of the lean cuts. Such a part-whole relationship would automatically generate a correlation of .54 in this data. The correlation within entries, breeds and seasons, between defatted ham percent and lean cuts percent was .89, representing an accurate prediction of one from the other. The regular skinned ham percent of chilled carcass weight would also be of utility, and especially suitable for carcass evaluation in the packing-house.

141. THE EFFECT OF FORCED EXERCISE ON CERTAIN CHEMICAL AND PHYSICAL CHARACTERISTICS OF PORK HAM MUSCLES. E. J. Briskey, R. W. Bray, W. G. Hoekstra, P. H. Phillips and R. H. Grummer, *University of Wisconsin*.

An animal exerciser was designed to exercise hogs of approximately market weight. Three experiments involving 44 hogs were conducted to study the effect of: various levels of forced exercise over a 4-day period; strenous exercise prior to slaughter under

full-feed and fasted conditions; and exhaustive exercise prior to slaughter, on certain chemical and physical characteristics of pork muscles. Samples of the gluteus profundus, gluteus accessories and gluteus medius ham muscles were removed from the carcasses at three different intervals. The following chemical and physical characteristics of these muscles were determined: myoglobin, glycogen, sodium, potassium, fat, moisture, pH, "free water" and color. The ham muscles from hogs exercised over a 4-day period showed no significant difference in myoglobin concentration, hydrogen-ion concentration or physical appearance. The muscles from hogs that received strenuous or exhaustive exercise immediately prior to slaughter were darker in color and firmer in structure. These muscles were significantly lower in hydrogen-ion and glycogen concentration at the fresh stage. The glycogen values of the controls and treated samples were similar after a 24-hour chill, however the hydrogen-ion concentration of the treated samples remained significantly lower. The control samples contained similar myoglobin and higher glycogen concentrations as fresh tissue. After the carcasses were chilled the controls were lighter in color, more watery in appearance and significantly lower in pH values. Additional data relating this type of stress to certain ham muscle characteristics will be discussed.

142. PHOTOGRAPHS FOR DETERMINING THE DEGREE OF MARBLING IN BEEF. J. R. Stouffer and G. H. Wellington, *Cornell University*.

Several representative photographs taken with polarized light have been selected to represent each of 12 scores for degrees of marbling in beef rib eyes. The series of photographs was collected to formulate an objective measurement technique for measuring degree of marbling. The photographs were made from steaks cut from the twelfth rib of the right side of the carcass. The steaks were taken from cattle of young maturity groups and representing Prime through Cutter grades. After photographing, steaks were cooked, juiciness and tenderness scores were obtained by a panel and shear force values were determined by the Warner-Bratzler Shear. The rib eye muscle was separated from the corresponding steak from the left side of the carcass and analyzed for moisture and ether extract. Relationships between carcass grade, outside fat thickness, rib eye area, and palatability scores were made. Data from 125 cattle have indicated the average ether extract percentage for each of the twelve marbling scores. Observations from the 64 cattle used for palatability studies indicated that marbling had a decided influence on juiciness, but the influence of marbling on tenderness was less pronounced.

143. SPECIFIC GRAVITY AS AN OBJECTIVE MEASURE OF MARBLING. L. E. Orme, A. M. Pearson, L. J. Bratzler and W. T. Magee, *Michigan State University*.

Specific gravity has been shown to be a good measure of carcass fatness, therefore, this study was undertaken to determine the usefulness of specific gravity as an objective measure of marbling. The *Longissimus dorsi* muscle was excised from the 9–10–11 rib of 31 steers, ranging from average Good to low Prime in grade. All exterior fat was removed and specific gravity was determined by the hydrostatic weighing technique. Weights were taken to 0.1 gram in air and 0.01 gram in water. Water was at room temperature for the first 16 ribeyes, while 6° C.±1° was used in all subsequent work. Fat, protein and moisture was determined by routine methods. Percentage fat in the ribeye varied from 1.90 to 8.42 and specific gravity ranged from 1.0573 to 1.0714. Correlation coefficients for specific gravity were −.81 with percent fat, +.73 with water and +.63 with protein. Thus results verify the usefulness of specific gravity as an objective measure of marbling. The regression of percent fat on specific

gravity is $\hat{Y}=(363.915)+(-336.920X)$. In order to get a better estimate of the regression of percent fat on specific gravity an additional 20 ribs will be included in these data. The high correlation between chemically measured fat percentage and specific gravity along with the relative simplicity of determination and the maintenance of the meat in a saleable condition emphasize the usefulness of specific gravity as an objective measure of total marbling.

144. THE RELATIONSHIP BETWEEN ENZYMATIC BREAKDOWN AND ACCEPTABILITY OF IRRADIATED BEEF ROASTS. R. G. West, A. M. Pearson and F. J. McArdle, *Michigan State University.*

Thirty-six roasts were prepared from the *Longissimus dorsi* muscle of wholesale beef ribs. One-third were cooked and injected with a beef press fluid enzyme preparation, one-third cooked and injected with an equivalent amount of the heat inactivated enzyme and the remaining third were uncooked. Two roasts from each group were used as unirradiated controls while the remainder were irradiated at 2.79 megarads. Amino nitrogen determinations were carried out on the roasts at different intervals of storage as a measure of enzymatic activity while simultaneously submitting them to taste panel evaluation. The taste panel found no significant difference between the unirradiated samples with mean scores ranging from 6.4 to 6.9, while amino nitrogen comprised from 7.4 to 7.6% of total nitrogen. After irradiation, panel scores were 5.3, 4.1 and 4.8 for the raw, cooked + active enzyme and cooked + inactive enzyme, respectively, while corresponding amino nitrogen values were 5.1, 6.1 and 6.8%. After one month's storage at 76° F., panel ratings were 3.3, 4.7 and 6.1 for the raw, cooked + active enzyme and cooked + inactive enzyme, respectively, while corresponding amino nitrogen values were 10.4, 7.4 and 5.7. Thus, results indicate that amino nitrogen and taste panel scores were inversely associated and show one of the major acceptability problems during storage of uncooked irradiated meat is continued enzymatic breakdown.

145. CONSUMER PREFERENCE AND ORGANOLEPTIC STUDIES AS RELATED TO FEDERAL BEEF GRADES AND SELECTED BEEF CARCASS CHARACTERISTICS. J. W. Cole, D. D. Brannan and C. S. Hobbs, *University of Tennessee.*

Thirty-six beef carcasses were selected, nine each from Choice, Good, Standard and Commercial grades. Each of the top three grades included six steers and three heifer carcasses and the commercial grade included only cow carcasses. Detailed measurements were made on one side of each beef. The left side of beef was used for physical separation into lean, fat and bone. The lean and fat were combined for chemical analyses determinations. Samples of broiling and braising steaks from the right side were used for organoleptic tests by a trained panel and forty selected families. A significant difference existed among grades for the following measurements: carcass length, length of leg, circumference of round, depth of sirloin, length and chest depth. Within the range of choice through standard grades, percentage of round and chuck decreased significantly while percentage of plate, brisket, kidney knob and flank showed a significant increase. Heifers and steers differed significantly in percentage of chuck, flank and kidney knob. Percentage of separable lean increased and fat decreased as grade changed from choice to standard. On a separable fat basis, heifer carcasses were significantly fatter than steer carcasses. Moisture percentages increased with an increase of the lean meat in the carcasses. Chemical fat determination followed the same trend as physical fat value. Heifer carcasses had significantly less moisture and more fat than steer carcasses. Data obtained from the trained taste panel and from family testing showed a preference for the higher grades of beef.

146. SLAUGHTER, CARCASS AND TENDERNESS CHARACTERISTICS AS INFLUENCED BY FEED INTAKE OF STEERS FED CHLORTETRACYCLINE AND/OR DIETHYLSTILBESTROL ON PASTURE AND IN DRY LOT. A. Z. Palmer, H. L. Chapman, Jr., J. W. Carpenter and R. H. Alsmeyer, *Florida Agricultural Experiment Station.*

One hundred and twenty-eight steers were fed in a split—split plot design. Half were fed on pasture and half in dry lot. One half of each of these two groups received a full feed of concentrates and the remainder restricted to six pounds of concentrate per day plus silage or pasture ad lib. Steers on each of these four feeding programs were subdivided into four lots of eight steers each. One lot received 90 mg. of Aureomycin per steer daily in the ration, one lot received 10 mg. of stilbestrol, one lot received stilbestrol plus Aureomycin while the control lot received no additives. Percentages of hide and liver, yield, cooler shrinkage, carcass length, thickness of chuck, length of leg, circumference of round, carcass grade, marbling, area and ether extract of the longissimus dorsi muscle at the 13th rib and tenderness by shear and panel were obtained. Breed differences were significant for all traits except area of longissimus dorsi and tenderness. Breed differences in panel tenderness score approached significance. The feeding of Aureomycin or stilbestrol showed no significant effect on any trait. Steers fed on pasture had greater circumference of round, greater rib eye area and a lower panel tenderness score. Limited feeding increased percentage of hide and cooler shrinkage whereas it decreased liver weight per unit of liveweight, yield and all carcass measurements except length. Limited feeding lowered carcass grade, marbling, area and ether extract of the longissimus dorsi muscle, and tenderness by shear test.

147. RELATIVE VALUE OF TALLOW, CORN AND COB MEAL AND VARIOUS LEVELS OF OATS IN RATIONS FOR GROWING SWINE. R. F. Sewell, T. E. Cotton, J. H. Maner and J. L. Carmon, *University of Georgia.*

Sixty weanling pigs were used in an experiment which employed six ration treatments on a completely randomized design. The ration treatments were as follows: 1, Basal (fortified corn-soybean oil meal type ration); 2, 5% tallow added to ration 1; 3, corn and cob meal replacing all of the corn of ration 1; 4, 12% oats replacing an equal quantity of corn in ration 1; 5, 24% oats replacing an equal quantity of corn in ration 1; and 6, 36% oats replacing an equal quantity of corn in ration 1. Two groups of five pigs each were used in replicate on each of the six ration treatments. Average daily gain and lb. feed per lb. of gain were as follows: (1) 1.53, 3.20; (2) 1.62, 2.92; (3) 1.33, 3.78; (4) 1.53, 3.29; (5) 1.45, 3.33 and (6) 1.30, 3.57. Statistical treatment of the data revealed highly significant increases in rate of gain for pigs on ration 1, 2 and 4 over rations 3 and 6. A significant increase in rate of gain was also found for pigs receiving ration 2 as compared to pigs on ration 5. There were no significant differences in gains of pigs receiving rations 1, 2 and 4, although ration 2 supported slightly faster gains. Pigs receiving ration 2 show a significant increase in efficiency of feed utilization over pigs receiving rations 3, 4, 5 and 6. Ration 1 produced a significant improvement in feed utilization as compared to rations 3 and 6. Significantly less feed was required by pigs on rations 4 and 5 to produce a lb. of gain than was required by pigs receiving ration 3.

148. RE-EVALUATION OF OATS IN RATIONS FOR GROWING-FINISHING SWINE. A. H. Jensen, D. E. Becker and S. W. Terrill, *University of Illinois.*

Comparison of a corn-soybean oil meal ration with rations containing 29, 60, and 95% ground oats for 100 lb. pigs in drylot resulted in average daily gains and pounds of feed per lb. of gain, respectively of 1.77, 3.67; 1.55, 4.20; 1.38, 4.44; and 1.26, 4.77. In a second trial using oats from a different source, growth rate and feed efficiency

were similarly decreased on the 60 and 95 but not on the 29% oats rations in drylot. However, on pasture the reductions in rate of gain for the three levels of oats were 18, 16, and 19%, respectively. Since all rations had been formulated for equal protein levels and adequate fortification, it appeared that the reduction in performance was due to the higher fiber content, and thus lower TDN value, of the oats rations. A feeding trial with 24 lb. and 32 lb. oats supported this supposition. Further, when, in two trials, pigs were individually fed hulled oats rations, daily gains were decreased 18% and 35%, respectively, with the addition of 15% and 30% oat hulls. Adding sufficient corn oil to correct the low TDN value of the 30% hulls overcame the growth reduction. Similarly, the depression of performance resulting from addition of oat hulls to a corn-soybean oil meal ration could be corrected by the addition of corn oil.

149. VALUE OF FEATHER MEAL WITH AND WITHOUT AMINO ACID SUPPLEMENTATION FOR GROWING-FINISHING SWINE. O. Glen Hall, *University of Tennessee.*

Three replicated experiments involving 180 weanling pigs have been conducted to determine the value of feather meal as a source of protein for growing-finishing swine fed in dry-lot and on pasture. Average daily gains and feed conversion values were used as response criteria. A basal ration of corn, soybean oil meal, meat and bone meal, alfalfa meal, vitamins, minerals and antibiotics was used. Feather meals, processed with steam or lime, and corn were substituted for one-third, two-thirds and all of the soybean oil meal in the basal ration on a protein equivalent basis. Performance of weanling pigs receiving rations in which feather meal replaced up to two-thirds of the soybean oil meal has been comparable to that of pigs on control rations. Similar results have been obtained where the feather meal rations were completely mixed and self-fed or where corn and protein supplements were fed separately. Replacing all the soybean oil meal with feather meal resulted in a decreased rate of gain ($P<.01$) and lower feed conversion values. In a recent experiment, the following rations were compared: (1) basal ration; (2) basal ration with feather meal replacing all the soybean oil meal; (3) same as 2 plus 0.2% added DL-lysine; (4) same as 1 plus 0.1% added DL-methionine; (5) same as 2 plus 0.2% added DL-lysine and 0.1% added DL-methionine. Rates of gain from weaning to approximately 150 lb. were as follows: 1.41, 1.31, 1.34, 1.49 and 1.30 lb. per head daily, respectively. Methionine supplementation resulted in a significant response in rate of gain ($P<.05$) by pigs on the high feather meal ration and a rate of gain comparable to that by the control pigs.

150. FEATHER MEAL AS A SOURCE OF PROTEIN FOR GROWING-SWINE. G. E. Combs, Jr., W. L. Alsmeyer and H. D. Wallace, *University of Florida.*

Rations which contained various levels of steam processed feather meal (FM) were given to 48 group fed (Experiment 1) and 24 individually fed (Experiment 2) weanling pigs. A basal ration composed essentially of yellow corn and soybean oil meal was used in both experiments. In Experiment 1 the average daily gain and feed efficiency respectively obtained from pigs fed the following ration treatments were: basal, 1.81, 3.53; 5% FM, 1.80, 3.42; 7.5 FM, 1.51, 3.76; 7.5% FM + Bovirum, 1.35, 3.60; 7.5 FM + .27% DL Lysine, 1.62, 3.39 and 10% FM, .76, 4.57. Similar data collected from Experiment 2 were: basal, 1.78, 3.43; 5% FM, 1.70, 3.36; 7% FM, 1.50, 3.53 and 7.5% FM + .46% DL Lysine 1.66, 3.33. The statistical analysis showed that in Experiment 1 pigs fed the 10% FM ration gained significantly less ($P<0.01$) than pigs on the other treatments and that there were no significant differences between pigs fed the basal, 5% FM and 7.5% FM + Lysine rations. The gains of pigs fed the unsupplemented 7.5% FM ration were significantly less ($P<0.01$) than pigs fed the basal and the 5% FM rations but were not significantly different from the

pigs receiving the lysine supplementation. In Experiment 2, pigs fed the unsupplemented 7.5% FM ration gained significantly less ($P<0.01$) than pigs on any other treatment. There were no significant differences between feed efficiencies of the various rations in either Experiment 1 or Experiment 2.

151. PHOSPHORUS AND PROTEIN LEVELS FOR GROWING-FINISHING SWINE ON LEGUME PASTURE. C. E. Jordan, J. H. Conrad, M. P. Plumlee and W. M. Beeson, *Purdue University*.

Seventy-two weanling pigs averaging 34 lb. in weight were allotted into six groups of 12 pigs each and self fed corn-soy rations containing different protein and phosphorus levels on good ladino clover pasture. The ration for lots 1, 2 and 3 contained 0.33, 0.45 and 0.60% phosphorus, respectively, and 14% protein to 100 lb., than 12% thereafter. For lots 4, 5 and 6 the ration contained 0.28, 0.45 and 0.60% phosphorus, respectively, and 10% protein to 100 lb., then 8.6% thereafter. U.S.P. grade monosodium phosphate was the source of supplemental phosphorus. Each ration contained 0.5% salt, 0.63% calcium, 7.5 mg. of chlortetracycline and 9 mcg. of B_{12} per lb. For the first 70 days daily gains were 1.11, 1.42, 1.42, 1.01, 1.26 and 1.26 lb., respectively, for lots 1 through 6 and the corresponding lb. of feed per lb. of gain were 3.2, 2.9, 2.7, 3.2, 2.7 and 2.7. Average daily feed consumption was 3.5, 4.1, 3.9, 3.3, 3.4 and 3.4 lb. for lots 1 through 6. The data show that: (1) Gains were increased 25% on the low protein and 28% on the high protein ration by raising the phosphorus level from 0.28 or 0.33 to 0.45%. Feed per lb. of gain was reduced 16 and 7.6% by the same treatment; (2) Feed per lb. of gain was reduced 6% when the phosphorus level was raised from 0.45 to 0.60% on the high protein ration but gains were the same. The 0.45 and 0.60% phosphorus levels produced equal results on the low protein ration; (3) The higher protein rations (lots 1, 2 and 3) increased daily gains 11.9%, and feed intake 13.6% but did not influence feed efficiency as compared to the low protein rations (lots 4, 5 and 6).

152. EFFICACY AND SAFETY OF ARSANILIC ACID IN CONCENTRATES FOR SWINE. Henry S. Perdue, Lacy R. Overby, Henry C. Spruth and Douglas V. Frost, *Abbott Laboratories, North Chicago, Illinois*.

Sixty-four feeder pigs of mixed Hampshire and Yorkshire breeding were allotted to 8 groups. Shelled corn and 30% protein concentrates prepared from a commercial concentrate were fed free-choice. To prepare the experimental concentrates arsanilic acid was added at the following rates: (1) None, (2) .05%, (3) .1%, (4) .15%, (5) .2%, (6) .25%. All concentrates contained 16.6 mg. of procaine penicillin G and 8.7 mg. of chlortetracycline per lb. Groups 1 and 2 contained 20 pigs each and the other groups contained 4 pigs each. After 92 days daily gains of the 6 groups averaged 1.56, 1.80, 1.82, 1.79, 1.68 and 1.41 lb. respectively. Average intakes of arsanilic acid throughout the feeding period for these 6 groups were 0, 53, 154, 216, 208, and 176 gm. per ton of total feed respectively. Corn to supplement intake ratios for groups 3, 4, 5 and 6 were 5.85, 6.25, 8.68 and 12.79 respectively. The increasing corn to supplement intake ratios, as consumed, automatically limited the intake of arsanilic acid by the last three groups, so that no clear-cut evidence of toxicity was seen either before or after slaughter. Arsenic analyses of the livers and kidneys from group 2 showed ranges of 0.52–2.36 and 0.28–0.86 ppm. As. For group 3 comparable values were 0.7–1.9 and 0.46–1.89 ppm. Only traces were found in muscle, brain, and spleen. An additional two groups of 4 pigs each were fed concentrates containing .05% and .1% of arsanilic acid on an intermittent basis. No evidence of toxicity appeared.

153. EFFECT OF VARIOUS ANTIBIOTIC COMBINATIONS AND OTHER BACTERICIDAL AGENTS ON GROWING-FINISHING SWINE. J. H. Conrad and W. M. Beeson, *Purdue University*.

Two experiments were conducted using 37 lb. Duroc weanling pigs fed for 84 days. Experiment 1—On concrete, six groups of 12 pigs each were full fed a basal ration of ground corn and Purdue Supplement 2 mixed to contain 16% protein to 100 lb. then 14% protein thereafter. The treatments, daily gains (lb.) and feed per 100 lb. of gain (lb.) were: Control, 1.42 and 327; chlortetracycline 20 gm./ton, 1.46 and 322; chlortetracycline 20 gm. + Na metaphosphate 60 gm./ton, 1.44 and 322; arsanilic acid 90 gm./ton, 1.54 and 311; chlortetracycline 10 gm. + arsanilic acid 45 gm./ton, 1.47 and 323; hygromycin 12 million units/ton, 1.54 and 306. Experiment 2—On alfalfa-ladino clover pasture, six groups of 12 pigs each were full fed a basal ration of ground corn and Purdue Supplement 2 mixed to contain 14% protein to 100 lb. then 12% protein thereafter. The treatments, daily gains and feed per 100 lb. of gain were: Control, 1.45 and 315; oxytetracycline 20 gm./ton, 1.56 and 295; furazolidone 50 gm./ton, 1.51 and 312; procaine penicillin 5 gm./ton, 1.64 and 300; procaine penicillin 5 gm./ton and streptomycin 15 gm./ton, 1.57 and 301; streptomycin 10 gm. and sulfaquinoxaline 10 gm./ton, 1.57 and 314. On concrete, arsanilic acid resulted in an 8% increase in gains and a 5% improvement in feed efficiency and hygromycin resulted in an 8% increase in gains and a 6% improvement in feed efficiency. On pasture, a combination of penicillin-bacitracin produced a 13% increase in gains and a 5% improvement in feed efficiency. Combinations of penicillin-streptomycin, streptomycin-sulfaquinoxaline and a single antibiotic, oxytetracycline, produced an 8% increase in gains.

154. EFFECT OF FURAZOLIDONE AND FAT ON PERFORMANCE OF GROWING-FATTENING SWINE. Kendall W. Scott, *University of Arkansas*.

Eighty crossbred weanling pigs were randomly allotted into 16 pens of 5 pigs each. There were eight treatments with one replication. The feeding period was 8 weeks. The treatments, average daily gains and the feed efficiencies were as follows: I.—Basal (B) consisting of corn, soybean oil meal, alfalfa and minerals 1.71, 3.30; II.—B + Chlortetracycline (C) 15 gm. per ton 1.75, 3.31; III.—B + Furazolidone (F) 20 gm. per ton 1.71, 3.65; IV.—B + F + C + 1.78, 3.62; V.—B + Fat (200 lb. stabilized animal fat added per ton at the expense of 200 lb. corn) 1.49, 2.91; VI.—B + fat + C 1.84, 2.80; VII.—B + fat + F 1.72, 3.03; VIII.—B + fat + C + F 1.92, and 2.75. Statistically significant differences in feed efficiency were found only with fat level of 10% ($P<.01$). The chlortetracycline produced a statistically significant difference in average daily gains ($P<.01$) with the interaction of fat and chlortetracycline approaching significance.

155. THE EFFECT OF FURAZOLIDONE UPON GROWTH AND FEED UTILIZATION IN GROWING-FATTENING PIGS. J. E. Briggs and J. E. Guthrie, *Hess & Clark, Inc., Ashland, Ohio*.

Levels of 10 to 50 gm. furazolidone (nf-180) per ton were compared as growth stimulants in a practical ration (no antibiotic). Three trials involving 148 purebred Yorkshire pigs were run in concrete pens. Trial 1: Average daily gain and feed per 100 lb. gain, respectively, for each lot of six pigs (initial weight, 56 lb.) fed 70 days were: (1) Basal—1.77 lb., 341 lb.; (2) 10 gm. antibiotics (5 gm. chlortetracycline + 5 gm. oxytetracycline per ton)—1.93 lb., 332 lb.; (3) 10 gm. furazolidone—1.85 lb., 316 lb.; (4) 20 gm. furazolidone—1.80 lb., 338 lb.; (5) 50 gm. furazolidone—1.94 lb., 350 lb.; (6) 10 gm. furazolidone + 10 gm. antibiotics—1.77 lb., 332 lb.; (7) 20 gm. furazolidone + 10 gm. antibiotics—1.79 lb., 324 lb.; (8) 50 gm. furazolidone + 10 gm. antibiotics—1.89 lb., 333 lb. The difference between certain treatments and the

basal approached significance. Trial II: Average daily gain and feed per 100 lb. gain for each lot of pigs (initial weight, 45 lb.) fed 84 days were: (1) Basal—1.43 lb., 387 lb.; (2) 10 gm. antibiotics—1.50 lb., 353 lb.; (3) 10 gm. furazolidone—1.44 lb., 376 lb.; (4) 20 gm. furazolidone—1.48 lb., 362 lb.; (5) 50 gm. furazolidone—1.64 lb., 343 lb. The growth rate was significantly greater in Lot 5 (50 gm. furazolidone) than in Lot 1 (basal). Trial III: Average daily gain and feed per 100 lb. gain for each lot of 10 pigs (initial weight, 93 lb.) fed 70 days were: (1) Basal—1.71 lb., 375 lb.; (2) 10 gm. antibiotics—1.78 lb., 372 lb.; (3) 20 gm. furazolidone—1.66 lb., 383 lb.; (4) 35 gm. furazolidone—1.73 lb., 386 lb.; (5) 50 gm. furazolidone—1.75 lb., 370 lb. Furazolidone or the antibiotics did not exert a marked growth response in 93 lb. pigs.

156. CHANGING DAIRY CALVES ONTO ALL DRY FEED AT AN EARLY AGE. R. D. Mochrie and W. R. Murley, *North Carolina Agricultural Experiment Station.*

Twenty-one male dairy calves of four breeds were fed dams milk for 3 days and thereafter raised to 63 days of age on a milk replacer (MR), pelleted calf starter, alfalfa hay regimen. All calves were fed alfalfa hay ad lib from the 8th day and calf starter up to 4 lb. per day for A and H and 3 lb. for G and J from the 15th day. The treatment groups consisted of: control—MR fed as a liquid thru 28 days of age; 8-day group—MR fed as a gruel for 4 days and as a dry pellet from 4 to 28 days; 15-day group—MR fed as liquid for 5 days, gruel for 6 days and as a dry pellet from 4 to 28 days. Dry pelleted MR was fed ad lib from 4 to 21 days and in limited amounts from 22 to 28 days to the 8-day and 15-day groups. The av. lb. of intake to 63 days for the control, 8-day and 15-day groups were: dry MR 22.7, 21.8, 22.4; calf starter 115.8, 112.3, 116.2, alfalfa hay 25.1, 22.0, 21.7 and calculated TDN 113.5, 108.6 and 111.7. Intakes to 28 or 63 days of age were quite variable, not significantly different for treatment groups but always lower for the 8-day group. The av. daily gains to 63 days of age were: 0.86, 0.70 and 0.91 lb. per day in the same order as above. The 8-day group gained at a slower rate than the 15-day group to 28 and 63 days of age ($P<0.05$).

157. EFFECT OF FEEDING OR IMPLANTING STILBESTROL ON THE PERFORMANCE OF SUCKLING BEEF CALVES. R. F. Hendrickson, L. S. Pope, A. B. Nelson, D. F. Stephens and D. C. Acker, *Oklahoma Agriculture Experiment Station, Stillwater.*

In three trials 5 mg. stilbestrol was added to the daily creep ration (milo, oats, cottonseed meal) of suckling beef calves which were sold as fat slaughter calves at 8 months of age. Two trials in which stilbestrol was added during the last 48 days on test (15 calves per lot) resulted in approximately 12% greater gain ($P<.05$), with no reduction in carcass yield or grade. In a third trial of 165 days (17 calves per lot) feeding stilbestrol increased gains 8% ($P<.05$) but gave a slight depression in carcass grade and yield. Uterine weights were significantly increased and number of developing follicles depressed in heifer calves fed stilbestrol. In four trials, 12–15 mg. implants of stilbestrol were given suckling beef calves at approximately 90 days of age. With one exception, the calves were not creep-fed. In the first trial (12 steer calves per group), weaning weights at 210 days were significantly increased ($P<.01$) and the implanted calves graded higher as feeders. Subsequent feedlot performance was not significantly affected by implantation as calves. In three trials with both steer and heifer calves (14–20 per group) gains at 45–60 days were significantly increased in two trials and approached significance in a third. The results indicate that young suckling calves can be successfully stimulated by stilbestrol, either fed or implanted, although the response may be less than with older cattle in the feedlot.

158. PRELIMINARY RESULTS ON THE MAINTENANCE REQUIREMENTS OF AGED BULLS AS INFLUENCED BY CONDITION. Herbert J. Rebhan and John D. Donker, *University of Minnesota.*

Present recommendations for maintenance requirements of farm animals are based on live weight only, and no allowances are made for the condition of the animals. One set of twin Guernsey bulls had been fed at 70% (T15) and 130% (T17) of Morrison's standards from the time they were 27 months old until they were 76 months old. Both bulls weighed about 800 lb. when they were 27 months old. Their weights when 76 months old were 1200 (T15) and 1800 (T17). At this time, the feeding of the bulls was changed in order to have both bulls at a common intermediate weight. When the bulls were 93 months old, their weights were 1458 (T15) and 1483 (T17). At this time the bulls were fed rations composed only of hay and grain in order to find out if the maintenance requirements would be similar. In order to cut down complimentary effects, hay and grain were fed at the same ratio to both bulls. Preliminary results indicate that the maintenance requirements of the fat bull (T15) were more than 8% higher than the thin bull (T17). The thin bull (T17) ate considerably faster than the fat bull (T15). The pulse rates were 100 for T15 and 60 for T17. Other observations indicate that perhaps creatinine excretion is not entirely related to protein mass.

159. DIGESTIBILITY OF RATIONS AND NITROGEN BALANCE BY LAMBS AS INFLUENCED BY ANIMAL FAT, UREA, SOYBEAN OIL MEAL AND LINSEED OIL MEAL. L. B. Embry, J. K. Turner and F. G. Gastler, *South Dakota Agricultural Experiment Station.*

Digestion and nitrogen balance trials were conducted using 12 wether lambs a total of 4 collection periods. Lard and urea were fed alone and in combination with rations, 11.5% protein, dry basis, containing linseed meal or soybean meal. There was no difference in digestibility of nutrients in rations containing soybean meal or linseed meal, with or without urea (0.9% of total ration). Five percent added lard significantly increased digestibility of crude protein and ether extract but depressed digestibility of crude fiber and nitrogen-free extract. Digestibility of total organic matter was not affected. The increase in digestibility of crude protein and ether extract apparently was enough to offset the depression in crude fiber and nitrogen-free extract digestibility resulting in rations higher in total digestible nutrients when lard was added. Lard improved digestibility of protein in the rations with urea to about the same degree as those without urea. Nitrogen balance data did not show any significant differences between treatments. The data were somewhat variable with urea resulting in the lowest nitrogen retention. Rations containing both lard and urea gave similar nitrogen retention values as for rations without urea.

160. FATTENING LAMB RESPONSES TO RATIONS FED IN VARIOUS PHYSICAL FORMS WITH SPECIAL EMPHASIS ON RUMEN CHANGES. G. B. Thompson, D. T. Lyons and W. H. Pfander, *University of Missouri.*

Lots of 86 lb. Texas lambs were self-fed 50% roughage rations as long hay-whole grain; coarse chopped hay-ground grain; pelleted hay-whole grain; all mash; and complete pellets. Within lot treatments included Hexestrol implants (6 & 12 mg.), entero-toxemia vaccination, and sex. Rumens of lambs fed the pelleted ration were larger, had thinner walls, possessed greater papillae development with openings in the rumen mucus membrane of papillae. Rumen tissue development and VFA analysis of rumen contents are related to physical form of ration. The average daily gains were .44, .42, .42, and .46 lb. for the long hay-whole grain, pelleted hay-whole grain, all mash, and complete pellets respectively. The feed efficiency was 6.3, 6.2, 5.9, and 5.2 for the same respective forms of the ration. In a second trial the feeding of coarse

chopped hay-ground grain produced an average daily gain of .45 and a feed efficiency of 6.1 as compared to .51 and 5.9 for this pellet fed group. Digestibility trials with mature wethers indicated the COD of cellulose to be 59.0, 62.1, and 53.2 (Sig. lower P .01) % for long hay, ground hay, and pelleted hay respectively. The COD of cellulose for the long hay-whole grain ration was 62.1 as compared to 46.6 for the complete pelleted ration. Six and twelve mg. Hexestrol implants significantly increased gains 20 and 32% respectively, while enterotoxemia vaccination and sex were without effect on gains. No enterotoxemia developed in any animals in this test. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1782. Approved by Director.

161. HISTOPATHOLOGY OF GOSSYPOL POISONING IN YOUNG PIGS. James T. Tollett, E. L. Stephenson and B. G. Diggs, *University of Arkansas.*

Crystalline gossypol was administered orally in capsule to crossbred baby pigs. The experimental material was fed in daily doses of 150 and 300 mg. per pig. Both levels resulted in death of the experimental animals in approximately 28 days with both levels being equally toxic. Post mortem examinations were made promptly after death and tissue samples taken for histological study. On macro examination the only organ which exhibited lesions was the kidney. This was covered with small petechial hemorrhages. Microscopic examination of kidney tissue revealed tubular degeneration. Also there was extension hemorrhage in the area of the pyramids. An additional experiment was conducted using only the 150 mg. level of gossypol. In this later trial appetite appeared to be retarded after two weeks. The pigs soon recovered, however, and no other symptoms of toxicity were noted. No explanation is offered for the apparent disagreement between the two feeding trials.

162. PALATABILITY OF BROAD-SPECTRUM ANTIBIOTICS FOR SWINE. J. H. Hare, R. P. Soule, Jr. and Hermann Zucker, *Chas. Pfizer & Co., Inc., Terre Haute, Indiana.*

Other investigators have indicated differences in palatability of rations containing different crystalline antibiotics where hogs had a choice of ration. In this laboratory a similar trial with the same levels of antibiotics, 40 gm. per ton, yielded mixed results. In one replicate pen, total consumption of oxytetracycline-containing feed was 2375 lb. and of chlortetracycline-containing feed 1648 lb. In the other replicate, these quantities were 954 and 2925 lb., respectively. With rations fed in separate pens, so that no choice was possible, total feed consumption was not influenced by type of antibiotic. The two replicates receiving oxytetracycline consumed 3736 and 3452 lb. and the two receiving chlortetracycline consumed 3729 and 3677 lb. The study was then extended to practical conditions, with the use of feed grade products supplying 40 gm. of the respective antibiotics per ton of feed, the animals being permitted a choice of rations. Feed consumption of oxytetracycline- and chlortetracycline-containing feeds were, respectively, 2754 and 932 lb. in Replicate 1 and 2668 and 726 lb. in Replicate 2. Daily rates of gain were improved by either the crystalline or feed grade antibiotic supplements and there was no statistical difference in growth response due to different antibiotics.

163. MYCOSTATIN, CHLORTETRACYCLINE, TRIIODOTHYRONINE AND OTHER GROWTH STIMULANTS FOR GROWING SWINE. H. D. Wallace, C. E. Haines, G. E. Combs, Jr. and W. F. Davis, *University of Florida.*

In the first of two experiments 80 weanling pigs were divided into eight lots of ten pigs each. Two replicated lots were self fed for a period of 77 days in small wooded contaminated pastures on each of four dietary treatments. The treatments,

followed by combined replicate averages for average daily gains and feed required per lb. gain respectively were as follows: I—Basal (fortified corn-soybean oilmeal ration), 1.73, 3.50; 2—Basal + 40 gm. chlortetracycline per ton, 1.75, 3.47; 3—Basal + 40 gm. mycostatin per ton, 1.77, 3.46; and 4—Basal + 40 gm. chlortetracycline and 40 gm. mycostatin per ton, 1.75, 3.54. There was a significant difference in gains ($P<.05$) between replicates but for the entire experiment the treatment differences for gains and feed conversion were not significant. In a second experiment conducted in drylot 64 pigs were divided into 16 lots of four pigs each with two lots being fed on each of eight treatments. The trial lasted 49 days. The treatments, followed by combined replicate averages for daily gains and feed required per lb. gain respectively were as follows: 1—Basal, 1.66, 2.86; 2—Basal + 125 mg. triiodothyronine per ton, 1.68, 3.01; 3—Basal + 250 mg. triiodothyronine per ton, 1.62, 3.10; 4—Basal + 500 mg. triiodothyronine per ton, 1.56, 3.27; 5—Basal + 50 gm. oxytetracycline per ton, 1.73, 2.94; 6—Basal + 50 gm. SQ-Strep. per ton, 1.72, 2.94; 7—Basal + 50 gm. Pro-Strep. per ton, 1.68, 2.90; and 8—Basal + 50 gm. mycostatin per ton, 1.63, 2.91. Triiodothyronine increased the amount of feed required per lb. gain at all levels studied and depressed gains at the high level (500 mg. per ton).

164. THE EFFECT OF VARIOUS LEVELS OF PROTEIN AND B-VITAMINS FOR GROWING-FATTENING SWINE. L. F. Tribble, *University of Missouri.*

A 4 x 4 factorial experiment was conducted to study the effect of four levels of crude protein, 18–14, 16–12, 14–10, and 16–12–10 and four levels of the B-Vitamins, riboflavin, pantothenic acid and nicotinic acid for growing fattening swine in dry lot. The vitamin levels used were (a) no vitamins added, (b) crystalline vitamins added to bring the calculated level up to the level recommended by NRC, (c) 2 times NRC recommended level and (d) 3 times NRC recommended level. The ration was made up of corn, soybean oil meal, tankage, minerals, vitamins A & D and an antibiotic, chlortetracycline. Protein levels were reduced when the pigs weighed approximately 100 lb. except for those on 16–12–10 where the changes were made at 75 and 150 lb. Five pigs of Hampshire and Duroc Breeding were fed in each pen from approximately 40 to 200 lb. The rate of gains of the pigs decreased with decreasing protein levels. Average daily gains were 1.45, 1.40, 1.41, and 1.33 for those on 18–14, 16–12, 16–12–10 and 14–10 respectively. These differences will be tested for significance. There were no apparent differences between pigs on the various vitamin supplements. Average daily gains were as follows: (a) 1.45, (b) 1.36, (c) 1.35 and (d) 1.41. Three Hampshire pigs were lost during the last part of the experiment from rather large bleeding stomach ulcers. Two of the pigs were on 14–10% crude protein, but on different levels of vitamins. The third pig was on the 16–12–10% level of protein. The relationship, if any, between this ulcerous condition and the feeding regimen is not shown. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1781. Approved by Director.

165. THE ABILITY OF GROWING-FATTENING SWINE TO BALANCE THEIR RATIONS WHEN SELF FED CORN AND PROTEIN SUPPLEMENTS CONTAINING VARYING AMOUNTS OF DEHYDRATED ALFALFA LEAF MEAL. H. P. Adams and R. E. Ward, *Eastern States Farmers' Exchange, Inc., Springfield, Mass.*

Ninety-four Yorkshire pigs weighing approximately 100 lb. were used in four feeding trials in which they were self fed corn and protein supplements varying in alfalfa leaf meal content from 2 to 20%. The pigs were kept in dry lot and were fed to an average weight of 200 lb. It was found that there was considerable variation in the amount of protein supplement consumed. As the percentage of dehydrated alfalfa leaf meal increased from 2, 5, 7, 10, 12, 15, 17, and 20%, the protein percentage of

the complete ration varied respectively from 14.8%, 12.4%, 11.5%, 14.2%, 15.2%, 12.6%, 16.9%, and 10.9%. In the two cases where the protein was below 12%, the average daily gains were adversely affected. There were no differences in lb. feed per lb. gain or in back fat thickness. The amount of supplement consumed was not related to its alfalfa content. The results indicate that pigs are not able to properly balance their rations when self fed.

166. THE EFFECTS OF FESCUE FORAGE AND SEED ON LABORATORY ANIMALS. M. C. Ball, C. S. Ma, G. M. Merriman and J. K. Underwood, *University of Tennessee.*

Since some fescue pastures have been toxic to cattle, studies were made using laboratory animals to determine if tall fescue forage, seed or extracts of forage and seed would give information on the toxic principles. The following tests were made with fescue forage: fresh fescue vs. fresh orchardgrass fed to chicks; fresh fescue juice fed to chicks and rats; the cocks comb and chemical tests for ergot alkaloids using extracts of fescue; injection of fescue and orchardgrass extracts into rats and chicks; and fungi cultures fed to rats. No positive results were obtained from any of these tests using fescue forage from toxic pastures. No ergot had been found in these pastures, however the symptoms of fescue toxicity in cattle are very similar to chronic ergot poisoning. When fescue fortified with protein, minerals and vitamins was compared with either fortified rye grass seed or stock ration for rats the average gains in three trials were: stock ration 162 gm.; fortified rye grass seed 130 gm.; fortified fescue seed 22 gm.; and fortified autoclaved fescue seed 77 gm. The only difference noted between the fescue and the rye grass lots was in growth. This growth depression in rats was not obtained from feeding either fescue seed ash, protein fractions of the fescue seed or from feeding the residue after obtaining the protein fraction. Infra-red spectrophotometer tracings of fescue seed and rye grass seed showed no differences. It appears that tall fescue seed contains a growth inhibitor for rats which may be partially destroyed by autoclaving or by treatment with dilute NaOH and HCl.

167. THE RELATIONSHIP OF PLANT COMPOSITION, RUMEN FLUID CHARACTERISTICS AND WEATHER TO THE INCIDENCE AND SEVERITY OF BLOAT. L. R. Brown, R. H. Johnson, R. S. Allen, N. L. Jacobson and P. G. Homeyer, *Iowa State College, Ames.*

Rumen ingesta samples were taken via stomach tube at regular intervals from 36 cattle on alfalfa pasture and 22 cattle on alfalfa soilage. Samples were collected in vacuum bottles; surface tension, foam volume, foam stability, ingesta volume increase and ammonia content were determined promptly. Weather observations included temperature, relative humidity, rainfall, cloudiness, wind velocity and moisture on the forage. Forage samples, taken twice weekly from the soilage and from locations selected at random in the pasture, were frozen and stored until analyzed for dry matter, nitrogen (non-protein, amino and total), reducing sugars, phosphorus and ash. Rumen fluid samples taken 2–3 hours after lard oil or soybean oil was fed in the grain or on the forage or when lard oil was fed in the drinking water (treatments that reduced bloat) showed a marked reduction in surface tension. Samples taken 12 hours after penicillin feeding suggested some reduction. There were no apparent effects of these treatments on other rumen fluid characteristics. There was a positive correlation between bloat severity and ammonia content of ingesta from untreated animals, but treatments which caused considerable reduction in bloat did not reduce rumen ammonia values. There was no apparent relationship between bloat severity and foam volume, foam stability or ingesta volume increase. Forage with high nitrogen and moisture contents was most bloat provocative. Bloat severity usually increased about one day after rain and decreased during hot weather; other weather measurements were not closely correlated with bloat.

168. EFFECTIVENESS OF MUCIN IN REDUCING THE INCIDENCE AND SEVERITY OF BLOAT IN CATTLE. E. E. Bartley, *Kansas State College.*

Frothing rumen contents from bloating fistulated cattle were placed in jars and incubated at 39° C. for 2 hours. Gas production was measured by water displacement. Additions of saliva, or mucilaginous extracts from linseed meal resulted in greater release of gas than when the rumen contents were incubated alone. Thus, linseed meal fed to cattle before pasturing legumes might prevent bloat by permitting a greater release of trapped gas. To test this supposition 24 heifers and dry cows were divided into two groups. One group of animals received 2 lb. linseed meal each, the other group served as a control. Both groups were pastured on alfalfa for 6 days. The total number of bloat cases was: control 19, linseed 3. The total bloat index (slight bloat=1, moderate=3, severe=5) was: control 50, linseed 5. Thirty-four lactating cows were divided into two groups and pastured on alfalfa for 3 days. One group of cows received from 1 to 2 lb. linseed meal for several feedings preceding pasturing, the other group served as a control. After 3 hr. of pasturing the total number of bloat cases was: control 37, linseed 26. The total bloat index was control 88, linseed 54. After 3 hr. in dry-lot the total number of bloat cases was: control 32, linseed 9. The total bloat index was: control 96, linseed 19. Feeding linseed meal to cows before pasturing appeared to reduce the incidence of bloat and cause the bloat to subside more rapidly. If froth formation in cattle while grazing legumes is due to a lack of salivary secretion, it may be postulated that mucin in saliva or linseed could be responsible for the protective action of these materials.

169. VALUE OF ROUGH RICE FOR FEEDER LAMBS AS AFFECTED BY FEED PREPARATION AND TYPE OF HOUSING. Maurice L. Ray and C. J. Brown, *University of Arkansas.*

Ninety-six white-faced southwestern feeder lambs were allotted to twelve treatments which made up a 3 × 2 × 2 factorial experiment repeated in two types of housing during a 106 day winter feeding trial. Forty-eight lambs were housed in a shed with no control of temperature while the other forty-eight were housed in an enclosed room where a temperature of approximately 70° F. was maintained. Pelleted and ground rations containing rough rice, corn, and an equal parts combination of corn and rough rice were compared. Lespedeza hay was fed in both the chopped and long form. Gains were greater ($P<.05$) when the energy was supplied by either corn or rice than when supplied by an equal parts mixture of these two grains. Differences were not explainable on the basis of consumption even though it was noted that a larger quantity of the rice ration was consumed in comparison to the corn ration. Gains were greater ($P<.01$) when lespedeza hay was chopped, even though consumption was not affected. Gains and feed consumption were not affected by preparation of the grain mixture. It was noted, however, that the grinding and pelleting of the grain portion of the ration influenced roughage consumption ($P<.05$) and gains ($P<.05$) in a different manner with rough rice rations than with corn. Hay consumption and gains were greater when pelleted rough rice was fed while they were greater when the corn ration was ground. Type of housing did not significantly affect feed intake or gains.

171. ANIMAL FAT AND PROTEIN SUPPLEMENTS FOR WINTERING BEEF CATTLE. Verle R. Bohman, Marvin A. Wade and Clark Torell, *University of Nevada.*

During the past two years seventy-two wintering Hereford calves were allotted to treatments in a 2 x 3 factorial designed experiment. The treatments involved two levels of inedible animal fat, 0 and 0.5 lb. daily, and three types of protein supplements, none, alfalfa, and cottonseed meal. The same amount of protein was supplied by the cotton-

seed and alfalfa supplements. The basal diet was native grass hay fed *ad lib*. A mineral mixture composed of equal parts of salt and bone meal was supplied free choice. The animals fed either type of protein supplement gained significantly faster than their controls during the winter. When the animals were ranged together the following summer the effect was reversed. However, at the end of the entire year, the cattle fed supplemental protein during the winter were still heavier. Added dietary fat had no effect on winter gains. The cattle that received fat during the winter gained faster the following summer. When supplemental protein was not fed, the level of hemoglobin and total cells in the blood decreased during the winter feeding period. The added dietary fat increased the plasma levels of fat, carotene and vitamin A. Dietary fat also caused a temporary decrease in the level of plasma phosphorus. The winter rations had no carry over effect on the level of plasma constituents after one month on summer range.

172. PROTEIN SUPPLEMENTS FOR WINTERING BEEF CATTLE. A. B. Nelson, M. G. Greeley, J. A. Miller and G. R. Waller, *Oklahoma Agricultural Experiment Station.*

A total of 501 head of grade Hereford beef cattle of different ages and sex have been used in a series of studies of the value of different protein feeds as supplements to native grasses or dry forage from these grasses. Most of the studies relate to the value of various feed additives in a basal cottonseed meal-corn supplement. Two levels of pelleted cottonseed meal (1 and 2 lb. for 2 years and 1.5 and 3 lb. for 2 years), a simple 20% protein pellet (corn-cottonseed meal), a complex 20% protein pellet (containing many sources of protein, minerals and vitamins) and a 40% protein-pellet having 50% of the nitrogen furnished by urea have been fed to five groups of cattle for 4 successive years, each group fed the same protein supplement in each of the years, in order to study long-time effects of the winter feeding different supplements. As measured by weight gain of the cows and weaning weight of the calves (born in the fall), the higher level of pelleted cottonseed meal has been the most desirable with the lower level of this supplement the least desirable and the remaining three supplements intermediate. Extensive studies with cattle grazing dried range grass have indicated that little, if any, urea was utilized when it was added to a basal pellet to furnish 1/3 of the supplemental nitrogen. However, when trace minerals were included in the urea-containing pellets, gains of the cattle were increased. In a single trial a similar response was noted when dehydrated alfalfa meal was added. When fed as a supplement to prairie hay, the urea-containing pellet was utilized to a considerable extent with apparently no improvement in utilization when trace minerals were added.

173. THE RESPONSE OF FATTENING YEARLING STEERS SELF-FED COMPLETE PELLETED RATIONS OF VARYING RATIOS OF CONCENTRATE TO ROUGHAGE. G. F. Cmarik, R. J. Webb and H. A. Cate, *University of Illinois, Dixon Springs Station.*

Sixty 700 lb. yearling steers were divided into four lots of 15 each and self-fed the following pelleted rations for 153 days in the winter of 1956–57: Lot 1—65% ground shelled corn, 25% ground hay, 10% SBM; Lot 2—55% ground shelled corn, 35% ground hay, 10% SBM; Lot 3—45% ground shelled corn, 45% ground hay, 10% SBM and Lot 4—same as Lot 2 except all ingredients were ground extremely fine. Average daily gains in lb. were 2.89, 2.85, 2.71 and 2.63 respectively. Pounds of pellets consumed daily were 21.1, 22.4, 22.6 and 21.3. Pounds of TDN required per cwt. gain were 524.5, 536.2, 541.4 and 553.7. Dressing percents and carcass grades were similar, being 59.1, 59.1, 59.2 and 59.6 and 6.5, 6.3, 7.0 and 6.9 respectively for Lots 1, 2, 3, and 4. Thus, it appears roughage can satisfactorily make up a relatively high percent of a fattening ration if offered in a form readily acceptable to the Steer. No ill effects were noted in the steers in Lot 4 which were fed the ration that was ground extremely fine before pelleting.

174. THE INFLUENCE OF CERTAIN PHYSICAL PROPERTIES OF PURIFIED CELLULOSE ON THEIR DIGESTIBILITY BY RUMEN MICROORGANISMS *IN VITRO*. Thomas I. Baker, Orville G. Bentley and A. L. Moxon, *Ohio Agricultural Experiment Station*.

An *in vitro* rumen fermentation (J. Animal Sci., 13, 581, 1954; J. Nutr., 57, 389, 1955) was used to study the comparative rate and total digestibility of samples of purified cellulose. Of the 20 purified cellulose samples studied, four samples were selected for detailed study. Cotton linters (Hercules Powder Company) a natural source of pure cellulose (97.5%) was found to be only 50% digested after 30 hours of fermentation. An isolated cellulose obtained from hardwood (BW40, Brown Company) was 70% digested; a softwood cellulose (SW40A, Brown Company) was 79% digested; and another wood cellulose (Raybond, Rayonier Corporation) was digested to 76% during a 30 hour fermentation. Analysis of variance showed these values to be significantly different at the 1% level. Time-rate studies over a continuous 60 hour fermentation period confirmed the 30 hour results; however, by 60 hours all the celluloses were completely digested. These data suggest that the physical nature of cellulose influences the rate of its digestion. Various treatments such as ball milling and swelling in alkali have been used to change the physical structure of the cellulose. The results of preliminary *in vitro* rumen experiments indicate that these treatments also changed the rate of digestibility (decreased). Physical measurements such as, degrees of polymerization and X-ray diffraction patterns, on the various celluloses will be obtained to determine if these measurements are different and if they show a relationship to the digestibility of the celluloses studied.

175. EFFECT OF VARIOUS AMINO ACIDS UPON *IN VITRO* CELLULOSE DIGESTION BY RUMEN MICROORGANISMS. Allen Trenkle, Edmund Cheng and Wise Burroughs, *Iowa State College*.

In vitro cellulose digestion studies have shown the presence of unidentified factors in different feedstuffs which stimulate cellulose digestion by rumen microorganisms. In the course of this investigation the effects of different amino acids on cellulose digestion were studied by using a washed suspension of rumen microorganisms. Among the amino acids tested, DL-proline, DL-alanine and DL-methionine have been found to consistently increase cellulose digestion by rumen microorganisms. The addition of methionine to a basal medium, containing an adequate amount of inorganic sulfur, was more effective in stimulating cellulose digestion than the addition of either proline or alanine. Combinations of methionine and alanine or methionine and proline have given responses equal to that of methionine alone. Seventeen other amino acids have shown no response upon cellulose digestion. These *in vitro* results with methionine and alanine were tested in a lamb feeding experiment making use of a purified diet. Increased liveweight gains were noted in the lambs supplemented with methionine which closely paralleled the increased cellulose digestion noted in the *in vitro* studies with methionine.

176. THE INTERRELATIONSHIP BETWEEN CALCIUM AND FAT IN RUMINANT DIGESTION. R. B. Grainger, T. W. White, F. H. Baker and J. W. Stroud, *University of Kentucky*.

A series of 3 digestion trials was conducted utilizing 4 wethers per treatment group. The feeding regimen included distilled water and a semi-purified basal ration composed of corncobs (65%), Drackett protein, urea, cornstarch, corn syrup, iodized salt, di-calcium phosphate, magnesium sulfate, sulfur and vitamins A and D. In trial I the replacement of corn syrup with 6% corn oil (CO) significantly decreased the digestibility of organic matter, cellulose and protein. Five percent CO significantly decreased organic matter and protein digestibility. A trace mineral mixture (TM)

containing Fe, Cu, Co, Mn, Zn and Mo equivalent to the amount contained in 30 gm. alfalfa ash (AA) reversed the effect of 5 and 6% CO on protein but not organic matter and cellulose digestibility. In trial II a significant depression of organic matter and cellulose digestibility by 5% CO was reversed by AA and Ca or Ca and P equal to that contained in AA. Ca or Ca and P significantly improved protein digestibility over the CO ration. TM or P did not alleviate the depression of digestibility of any ration component studied. In trial III, Ca or Ca and P completely reversed the depression of organic matter and cellulose digestibility illicited by 5% CO. Ca and P significantly improved the digestion of protein over the CO ration. Ca or Ca and P did not improve the digestibility of the basal ration. To maintain optimum digestibility of ration components in the presence of CO the ruminal requirement for Ca is increased.

177. EFFECT OF STARVATION AND SUBSEQUENT REFEEDING ON SOME *IN VITRO* ACTIVITIES OF RUMEN MICROORGANISMS. J. C. Meiske, R. L. Salsbury, R. W. Luecke and J. A. Hoefer, *Michigan State University*.

Samples of rumen fluid were collected from a fistulated steer fed: (1) a high-roughage ration regularly, (2) no ration for three days, (3) a high-roughage ration following starvation. The ability of rumen fluid to digest cellulose *in vitro* and to reduce the viscosity of a carboxymethylcellulose (CMC) suspension was determined. A fraction (S-1) freed of protozoa, plant material and bacteria were also tested for activity against CMC. During starvation the pH of the rumen fluid rose to between 7.65 and 7.94, cellulose digestion *in vitro* was greatly reduced, and the CMC activity of all fractions became progressively lower. When feeding was resumed, the pH of the rumen fluid decreased, cellulose digestion *in vitro* returned to normal in one to three days, and all fractions showed unusually high, but approximately equal CMC activity, indicating that the enzymes attacking CMC were largely extracellular at that time. The CMC activities generally returned to normal in two to four days after feeding had been resumed. No differences could be attributed to the type of hay fed before or after starvation. The steer readily consumed all of his ration at each feeding.

178. PHYSICAL FACTORS THAT INFLUENCE THE RESPONSE OF SHEEP TO ADDED CORN OIL. W. H. Pfander and I. S. Verma, *University of Missouri and Lincoln University*.

Twelve mature fistulated crossbred wethers were fed, in grams per day: cottonseed hulls, 900; casein, 90; $CaHPO_4$, 9; salt, 10; and Vitamin A & D source 1.3. Six sheep received trace mineralized salt, and six plain salt. Digestibility trials were based on six day total collections following 14 day preliminary periods. A second trial was conducted while the sheep were receiving 46 grams of corn oil, mixed with the cottonseed hulls or poured into the rumen. The coefficients of digestibility on the basal ration, the ration with fat added to the hulls and with fat added through the rumen fistula were: organic matter 50, 35, 50; cellulose, 52, 29, 49; nitrogen, 51, 35, 50. Digestibilities were significantly higher on the basal ration containing no trace salts, but were lowered to a greater extent by the fat when trace salts were present, thus the action of fat was shown to be associated with both the mineral and fiber utilization. Samples of rumen ingesta were removed after each trial at 0, 5.5, and 12 hours after feeding. Fermentation was stopped and the fat was extracted. Within five hours after feeding the corn oil had been hydrogenated to the extent that it was solid at room temperature. Iodine and saponification numbers are in agreement with this finding. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1784. Approved by Director.

179. EVALUATION OF THE TECHNIQUES USED IN THE OHIO *IN VITRO* RUMEN PROCEDURE. Ronald R. Johnson, Burk A. Dehority and Orville G. Bentley, *Ohio Agricultural Experiment Station.*

Studies on the *in vitro* rumen fermentation procedure used at the Ohio Station (J. An. Sci., 13:581, 1954; J. Nutr. 57:389, 1955) were made to determine the effect of (1) various methods for preparing the inoculum, (2) aeration and pre-incubation of the inoculum, and (3) fatty acid end products on cellulose digestion. Previously, the inoculum was prepared by pressing the liquid from rumen contents, supercentrifuging the liquid, and resuspending the sediment in buffer. A more active inoculum for cellulose digestion was prepared by discarding the first liquid, resuspending the pressed rumen contents in buffer, and pressing out this liquid for the supercentrifugation. Tests on levels of this inoculum revealed that an amount equivalent to 50 gm. of the pressed rumen content per 100 ml. of medium gave 40% better cellulose digestion than the previous inoculum. Attempts to wash these cells showed that one washing reduced the cellulolytic activity to about one third of the original and a second washing destroyed practically all activity. The inoculum could be aerated up to 20 minutes and incubated in air at 37° up to two hours before any appreciable loss of cellulolytic activity occurred. Acetic, proprionic and butyric acids were tested at various levels to determine if these end products of digestion were inhibitory. Used singly, these acids were not inhibitory at 300 mg. per 100 ml. medium. When used in combination, levels over 200 mg. of each acid per 100 ml. medium were found to be inhibitory. Previous reports had shown straight and branched chain C_5 and C_6 acids at 10 to 30 mg. per 100 ml. to be stimulatory for cellulose digestion. Recent experiments show that propionic acid has some cellulolytic activity and butyric acid showed marked activity at levels around 100 mg./100 ml. medium.

180. THE RETROGRESSION OF THE RUMEN OF DAIRY CALVES FOLLOWING THE SUBSTITUTION OF MILK FOR A HAY-GRAIN DIET. H. N. Harrison, R. G. Warner and J. K. Loosli, *Cornell University.*

Six Holstein bull calves were reared to three months of age on a basal milk diet plus a dry ration consisting of 91% hay and 9% dry-calf starter. They were divided into three pairs and either (1) slaughtered immediately, (2) confined on elevated wooden platforms and milk substituted for the dry feed, or (3) maintained on the dry feed as before for 20 weeks. Two additional calves (4) were raised on milk alone until six months of age. The data from groups (1) and (3) were similar and have been pooled. At slaughter, the rumen papillae of groups (1) and (3) were normal while (2) and (4) were rudimentary. A section of rumen wall just caudal to the rumino-reticular fold was taken and the air dry weight of the mucosal and muscle layers determined. The percent mucosa was respectively for each treatment, (1 and 3) 66.8, (2) 38.4, and (4) 34.3. The total volume of trimmed, washed, deflated tissue in liters per 100 kg. of empty body weight was averaged for each treatment and was respectively for the reticulo-rumen, omasum abomasum, and intestines (1 and 3) 3.5, 1.4, 0.6, 5.7; (2) 1.5, 0.2, 0.6, 5.2; and (4) 1.2, 0.2, 0.6, 4.6. These observations clearly show that following the substitution of milk for a hay-grain diet the reticulo-rumen and omasum retrogress to an undeveloped condition similar to that of a milk fed calf. The abomasum and intestines appear to develop only in relation to body weight.

181. EFFECT OF GRADE AND BREED OF CATTLE ON GLYCOGEN, LACTIC ACID, NUCLEIC ACIDS AND PHOSPHOLIPID PHOSPHORUS. R. L. Shirley, A. Z. Palmer, J. W. Carpenter, F. M. Peacock, W. G. Kirk and G. K. Davis, *University of Florida.*

Brahman-Shorthorn crossbred cattle of various grades were slaughtered at 14 to 18 months of age. The crossbreeding varied from 7/8 to 1/8 Brahman. Some were fed

in dry lot a cottonseed meal-citrus pulp-corn meal-alfalfa-pangola hay ration; while some were on pasture and supplemented with cottonseed meal and citrus pulp. Tissues were anlyzed for various constituents to determine the influence of breed and grade. The higher the grade, the greater the amount of glycogen in the liver; standard, good and choice grades had essentially the same glycogen content in the heart and gracilis muscle. The higher the grade, the less lactic acid in the heart; grade was not observed to affect the lactic acid of the liver and muscle. Ribo- and desoxyribonucleic acids were not affected by grade or crossbreeding in the heart and muscle. The higher the grade, the greater the phospholipid phosphorus and fat in the muscle. The greater the percentage of Brahman, the less the glycogen in the muscle; breeding was not found to effect the glycogen of the heart and liver.

182. METHODS OF DETERMINING DRY MATTER OF FRESH FORAGES AND SILAGES. G. E. Mitchell, Jr., J. L. Williamson, A. L. Neumann and H. W. Norton, *University of Illinois.*

Toluene distillation, drying under vacuum at 95° C., drying in a 105° C. oven, and drying in an air blast cabinet dryer at 46° C. and 54° C. were used to determine the dry matter content of 5 alfalfa-corn mixtures, both before and after ensiling. The silage mixtures contained alfalfa plus 0, 5, 10, 20 and 40% ground shelled corn. No significant difference between methods of determining dry matter were detected in any silage mixture except the silage containing 10% corn. In this silage, vacuum drying resulted in significantly lower silage dry matter determinations than drying at 46° C. or 54° C. Since vacuum drying resulted in intermediate determinations in the 20 and 40% corn mixtures and only slightly lower values than other drying methods in the 0 and 5% corn mixtures, it is evident that vacuum drying was not very different from the other methods. Variations in dry matter determinations from toluene distillation were accentuated by the necessity of weighing wet samples, the difficulty of collecting all water droplets in the receiving tube, and the inability to accurately read water volumes to .01 ml. The data indicated no advantage in determining dry matter by the more tedious toluene distillation method.

183. THE COMPARATIVE EFFECTS OF DIETHYLSTILBESTROL AND PROGESTERONE-ESTRADIOL BENZOATE IMPLANTS ON FATTENING STEERS FED VARYING RATIOS OF CONCENTRATE AND ROUGHAGES. R. J. Webb, G. F. Cmarik and H. A. Cate, *University of Illinois, Dixon Springs Experiment Station.*

This test was designed to study the effects of stilbestrol and progesterone-estradiol benzoate implants on yearling steers being self-fed rations that varied in ratio of concentrate to roughage. Four lots of 15 yearling steers each were self-fed the following pelleted rations for 153 days: Lot 1—65% shelled corn, 25% gr. hay, 10% SBM; Lot 2—55% shelled corn, 35% hay, 10% SBM; Lot 3—45% shelled corn, 45% hay, 10% SBM, Lot 4—same as Lot 2 except the ingredients were very finely ground before pelleting. The steers were started on feed Oct. 30, 1956 and implanted Nov. 27, 1956. Five steers in each lot were implanted with 48 mg. diethylstilbestrol, five with 1000 mg. progesterone—20 mg. estradiol benzoate and five were left in each lot as controls. Overall average daily gains were 2.54 for the controls, 2.67 for progesterone-estradiol and 3.10 for stilbestrol. Dressing percents were 59.7, 59.0 and 58.9 respectively. Carcass grades were 7.0, 6.6 and 6.5. Stilbestrol gave the largest increase in daily gains on the high concentrate ration, gains being 3.59, 3.13, 2.68, 2.98 lb. respectively in Lots 1, 2, 3, and 4. A similar pattern was not followed with the progesterone-estradiol benzoate implants. Average daily gains were 2.63, 2.85, 2.78, 2.42 lb. respectively. Average daily gains in the controls were 2.44, 2.59, 2.65, and 2.50 lb. respectively in Lots 1, 2, 3, and 4.

184. REPLACEMENT VALUE OF HIGHER OIL-HIGHER PROTEIN CORN IN RATIONS FOR LAMBS. E. W. Dayton, V. E. Chappell, E. E. Hatfield and U. S. Garrigus, *University of Illinois.*

Grade Suffolk lambs weighing between 69 and 75 lb. were used in a nitrogen balance experiment. A ration containing higher oil-higher protein corn was compared with rations containing regular corn and regular corn supplemented with energy and/or protein at levels to equal energy and/or protein of the higher oil-higher protein ration. The lambs were kept on a constant feed intake. Each collection period was of 6 days duration, proceeded by an eight day preliminary adjusting period. Apparent digestion coefficients were determined for dry matter, nitrogen, ether extract, and crude fiber. The nitrogen retained by lambs receiving the higher oil-higher protein corn ration was significantly greater ($P<0.01$) than by lambs receiving the other test rations. The apparent digestion coefficients for dry matter and crude fiber were highest ($P<0.01$) for the regular corn ration which was supplemented with additional protein. The apparent digestion coefficients of ether extract were higher in the higher oil-higher protein corn ration and the regular corn ration supplemented with additional energy than in the regular corn rations with or without protein supplementation.

185. THE INFLUENCE OF TWO LEVELS OF FEEDING ON THE EFFICIENCY OF RATION UTILIZATION. J. H. Byers and N. L. VanDemark, *University of Illinois.*

Twelve bulls ranging from 12 to 19 months in age were used in a series of digestion trials. Six animals were fed at 60% and 6 at 100% of the mid-point of Morrison's requirements. Thirteen observations were at the 60% and 13 at the 100% level of feeding. Three observations were made on each of 6 animals, two on each of 2 animals and one on each of 4 animals. The ration consisted of good quality alfalfa hay fed at the rate of one lb. per 100 lb. of body weight and a concentrate mixture to meet the requirements but never in excess of 6 lb. per animal per day. Collections were taken for five days and the usual proximate analyses made. Digestion coefficients at the 60% and 100% levels of feeding were dry matter, 66.4, 70.4; crude protein, 76.6, 75.6; ether extract, 69.5, 72.2; crude fiber, 38.3, 52.7 and NFE, 76.4, 78.7 respectively. Only the crude fiber was significantly different and this was in favor of the 100% level of feeding. The explanation of this marked difference in fiber digestibility is not, as yet, apparent but is being investigated. Considering the ration as a whole, feeding bulls at 60% and 100% of the mid-point of their requirements did not significantly influence the efficiency of ration utilization.

187. DRIED ACTIVATED SEWAGE SLUDGE AS A NITROGEN SOURCE FOR RUMINANTS. L. R. Hackler, A. L. Neumann, E. E. Hatfield and B. Connor Johnson, *University of Illinois.*

Soybean oil meal, urea and dried activated sewage sludge were compared in a 4 x 4 latin square design nitrogen balance and digestion experiment with sheep. Urea (2/3 of supplemental N) plus sewage sludge (1/3 of supplemental N) made up the supplemental N in a fourth ration tested. The basal ration contained the following major components: ground corn, crushed oats, corn cobs, cerelose, granulated starch, and dehydrated alfalfa meal. The basal ration contained about 6% crude protein. This crude protein was increased to approximately 9% by the various nitrogen supplements tested. Starch was added to the urea and sludge ration to equalize the energy intakes, and Na_2SO_4, was added to equalize sulfur intakes. The experimental animals were 8 native yearling lambs, weighing between 80 and 84 lb., initially. Each pair of lambs received in different periods each of the 4 experimental rations. Each collection period was of 7 days duration, preceded by a preliminary period of 14 days. The apparent nitrogen digestion coefficients were: soybean oil meal ration (A) 58.5, urea ration

(B) 60.5, sludge ration (C) 40.0, and urea-sludge ration (D) 53.5. The calculated biological values of the nitrogen were: A—69.0, B—57.7, C—66.6, and D—63.4. At this high level of dried sewage sludge some reduction in acceptability of the ration was encountered. Results of a fattening trial will also be presented.

188. PREPARTUM AND POSTPARTUM SERUM MINERAL LEVELS IN COWS DEVELOPING SEVERE MILK FEVER SYMPTOMS. K. A. Kendall and K. E. Harshbarger, *University of Illinois.*

Serum calcium, inorganic phosphorus and magnesium levels were determined daily in three aged Jersey cows, beginning 9–14 days before parturition. The average prepartum serum calcium levels, in mg. percent, in relation to inorganic phosphorus levels, respectively for the 3 cows (1, 2, 3) were: (1) 10.2:8.39; (2) 11.3:9.13; and (3) 12.5:9.41. Prepartum calcium levels, in mg. percent, in relation to maximum phosphorus levels, respectively reached on any one day were: (1) 10.9:11.20; (2) 11.2:12.26; and (3) 12.8:12.20. All three cows developed severe milk fever cases on day 1 following parturition. Calcium as related to phosphorus levels in mg. percent, respectively declined to: (1) 4.7:0.32; (2) 5.3:1.99; and (3) 6.9:1.29 following the onset of milk fever symptoms. Prepartum magnesium levels, in mg. percent, averaged: (1) 3.6; (2) 3.1; and (3) 3.0 while levels during milk fever attacks reached (1) 4.78; (2) 2.45; and (3) 4.18 mg. percent. All cows responded temporarily to calcium gluconate treatment. Two to three hours following treatment the alleviation of milk fever symptoms was associated with normal serum calcium, phosphorus and magnesium levels. This response was followed by repeated relapses and finally death.

189. EFFECT OF CHLORTETRACYCLINE ON THE METABOLISM OF DAIRY CALVES WITH PARTICULAR REFERENCE TO CALCIUM UTILIZATION. L. J. Bush, N. L. Jacobson and R. S. Allen, *Iowa State College.*

Sixteen male calves were paired according to breed and initial body weight and the members of each pair were randomly assigned to a chlortetracycline or control group. Whole milk was fed until 7 weeks of age. Alfalfa hay was fed *ad libitum* and a calf starter was fed free choice up to a maximum of 4 lb. per day. Approximately 80 mg. of chlortetracycline was added to the milk of each calf daily during the first 6 weeks and thereafter this amount was fed in the calf starter. Digestion and nitrogen retention trials were conducted during the 5th, 8th and 11th weeks. During these same periods, the average blood reducing sugar values were somewhat higher and the blood NPN values were slightly lower for the chlortetracycline group. At the beginning of the 12th week each calf was given orally 5 mc. of Ca^{45} to study calcium metabolism and measure bone growth. Blood levels of Ca^{45} (expressed as percent of administered dose either per 100 ml. blood or in estimated total blood) were higher in the control group during the 24 hours following administration. Radioautographs were made from a tibia and femur of each calf following sacrifice at 16 weeks of age. During the 16-week period the average weight gain was 164.5 lb. for the calves receiving chlortetracycline and 146.1 lb. for the controls. The gain in height at withers for the first 11 weeks was 11.9 and 10.3 cm. for the two groups, respectively. Feed consumption was greater for the group receiving chlortetracycline.

190. WET AND DRY POTATO PULP IN A STEER FATTENING RATION AND QUALITY OF CARCASSES PRODUCED. H. H. Brugman and H. C. Dickey, *University of Maine.*

Twenty steers were equally divided into two groups for a 157-day fattening trial. Group I was fed dried potato pulp, free choice, 2 lb. of linseed oil meal (L.O.M.) and 5 lb. of hay per animal per day. Group II was fed wet potato pulp, free choice, 2 lb.

of L.O.M. and 5 lb. of hay per animal per day. Both groups received trace mineralized salt free choice. Group II did not have access to drinking water. Average daily gain per animal was 2.11 and 1.99 lb. Feed cost per lb. of gain was 20.7 cents for the dry pulp group and 10.3 cents for the wet pulp group. Carcass tests showed no significant differences in aroma, tenderness and flavor as established by a taste panel. Carcass grades were U.S. Good to U.S. Choice. The chemical compositions of dried and wet potato pulp approaches that of U.S. No. 2 corn on a dry basis. This year enough potato pulp was dumped into the rivers of Maine to feed 120,000 steers.

191. EFFECT OF POTASSIUM OROTATE AND METHIONINE IN SUCKLING AND FATTENING LAMB RATIONS. R. M. Jordan, *University of Minnesota.*

Two trials with fattening lambs and two trials with suckling lambs were conducted to determine the effect of orotic acid and methionine on growth rate and feed consumption. In the fattening trials, potassium orotate and methionine were mixed with soybean meal at a level to provide 400 mg. of each of orotic acid and methionine per lamb daily in Trial 1, and 300 mg. each of orotic acid and methionine in Trial 2. Average daily rates of gain were: Trial 1, (84 days) control .417 lb., and treated .387 lb.; Trial 2, (56 days) control .400 lb., and treated .435 lb. The difference in rates of gain was not significant in either trial. Feed consumption was not affected by treatment. In the two creep trials, 4–5 week old lambs weighing 18 to 20 lb. were allotted to treatment on the basis of sex, age and breed. The creep ration consisted of equal parts of coarsely ground corn and oats and .1 lb. of soybean meal per lamb daily. The potassium orotate and methionine were mixed with the soybean meal at a level to provide 200 mg. each of orotic acid and methionine per lamb daily. The average daily gains were: Trial 1, control .576 lb. and treated .613 lb.; Trial 2, control .560 lb. and treated .562 lb. The difference in rates of gain was not significant in either creep trial. More feed was consumed by the treated lambs during the first 28 days of the trial. However, their feed consumption declined materially during the last six weeks of the trial.

192. INTERCHANGEABILITY OF HIGH AND LOW QUALITY ROUGHAGES FOR FATTENING STEERS. I. A. Dyer and M. E. Ensminger, *State College of Washington.*

Twenty-four yearling steers were divided into 4 groups of six steers each and individually fed for 84 days. All rations were composed of 70% pelleted concentrate and 30% chopped roughage. Rations 1–4 were composed of 30–0; 20–10; 10–20; and 0–30% alfalfa and wheat straw, respectively. Groups 2, 3, and 4 were supplemented with urea, vitamin A and trace minerals in amounts equal to that supplied by the basal ration. No attempt was made to equate the energy content of the various rations. Rates of gain for groups 1–4 were 2.48, 2.61, 2.26 and 2.39 lb. per steer daily, respectively. Feed required per lb. of gain for the above treatments was 7.3, 8.3, 9.2 and 9.6 lb.

193. THE ROLE OF BUTYLATED HYDROXY ANISOLE AND SODIUM META BISULFITE IN THE UTILIZATION OF RATIONS CONTAINING NITRATE. J. L. Ketchum, G. B. Garner, L. M. Flynn and W. H. Pfander, *Missouri University.*

Three Shropshire (mean weight 57.5 lb.) and four cross bred (mean weight 100 lb.) wethers were used to study the effects of butylated hydroxy anisole (BHA), sodium meta bisulfite and source of nitrate on nitrate utilization. The basal ration contained 67.5% ground grass hay, 10.2% blackstrap molasses, 20.3% ground yellow corn, 1.0% salt, and 1.0% dicalcium phosphate. Potassium, ammonium, and sodium

nitrate were added at levels of 1.5, 1.75, and 2.0%. Nitrogen balances were calculated and blood samples were analyzed for nitrate. There was no indication of either ammonia or nitrate toxicity. Average coefficients of digestibility of nitrogen in the rations were: ammonium nitrate 64.8, sodium nitrate 58.7, and potassium nitrate 55.9. When 0.01% BHA was added to the potassium nitrate containing rations, digestion, absorption, and retention of ration nitrogen were improved. Analysis of the blood revealed a much lower nitrate concentration when BHA was fed. Digestion and/or absorption of ration nitrogen was increased with the addition of sodium meta bisulfite. The percent of the intake nitrogen excreted in the feces decreased and the percent nitrogen retention increasd. Blood Vitamin A levels were determined on each ration, and although within the normal range, show some variation with treatment. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1786. Approved by Director.

194. THE TDN OF RATIONS CONTAINING SHELLED, CRACKED, GROUND, AND FLAKED CORN AS DETERMINED WITH SHEEP. R. Fisher, C. W. Gehrke, M. E. Muhrer and W. H. Pfander, *University of Missouri.*

Twelve mature fistulated cross bred wethers were fed a ration of 800 gm. chopped U.S. No. 3 alfalfa hay, and 400 gm. corn with salt and water *ad libitum*. The corn was fed in four forms: shelled, cracked, ground, and flaked. Fourteen day preliminary periods were followed by 6 day total collections. The total digestible nutrients present in the rations containing the various corns were: shelled, 61.9; cracked, 62.6; ground, 62.1; flaked, 64.6. There were no significant differences between the shelled, ground, or cracked corn rations. The higher TDN in the flaked corn ration was due primarily to increases in the coefficient of digestibility of NFE and fat, and to a slight but significant increase in protein digestibility. The coefficients of digestibility of protein, NFE, fat and fiber in the shelled and flaked corn rations were respectively: 72, 73; 72, 75; 59, 66; 56, 58. The percent of each digestible nutrient in the corns calculated by the difference method are given. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1783. Approved by Director.

195. EFFECT OF ADDING VITAMIN A AND PHOSPHORUS TO SUPPLEMENTS FED WEANED HEREFORD STEER CALVES GRAZED ON WINTER RANGE. O. O. Thomas, R. R. Woodward, G. F. Payne, J. R. Quesenberry and F. S. Willson, *Montana Agricultural Experiment Station and U.S. Range Livestock Exp. Sta.*

Two experiments were conducted with weaned Hereford steer calves grazed on native winter range at the U.S. Range Livestock Experiment Station. In Trial I, conducted from December 15, 1955 to April 19, 1956, forty weaned Hereford steers were divided into four groups; all steers were grazed together and each morning were separated into stalls in a chute for individual feeding. Each steer was fed two lb. per day of 20% protein pellet as follows: Lot 1, control pellet; Lot 2, control pellet fortified with 5,000 I.U. vitamin A per lb.; Lot 3, control pellet fortified with 1% additional phosphorus; and Lot 4, control pellet fortified with both vitamin A and phosphorus. Average daily gains for steers during the 140-day period were 1.13, 1.22, 1.29, and 1.32 lb., respectively. Blood plasma levels reflected phosphorus supplementation but not vitamin A. In Trial II, conducted from December 15, 1956 to April 18, 1957, forty weaned Hereford steer calves were grazed together on native range and individually fed the same supplements as the previous year. Average daily gains made during the 140-day period for Lots 1, 2, 3 and 4 were 0.83, 0.87. 0.90, and 0.93 lb. respectively. Differences in gain among lots were not significant either year; however, the trend was the same each year with the addition of vitamin A and

phosphorus to the supplement increasing weight gains. Grass provided about three-fourths of the winter forage with Western wheatgrass being the most important. Grass species analyzed contained less than 4% protein, .05% phosphorus and contained only a trace of carotene during most of the trial.

196. THE METABOLISM OF CALCIUM AND PHOSPHORUS AS AFFECTED BY ZINC AND ALUMINUM IN RATIONS FOR SHEEP. Sam L. Hansard, Alan Thompson and M. C. Bell, *University of Tennessee.*

Twelve wether lambs were used in a series of four balance trials to investigate the the effects of two levels of aluminum and zinc upon calcium and phosphorus absorption and retention. In each trial the basal ration, the basal ration plus added aluminum and the basal ration plus added zinc were fed. In two trials 1.0% zinc sulfate and aluminum sulfate, respectively, were fed, and in the other two trials the ration additives were at the 0.5% level. Chemical and radio-chemical calcium and phosphorus balance data and blood concentration values were followed, and employed to calculate the endogenous fecal excretions and true digestibilities. Marked decreases in net retention, apparent and true digestibility of calcium were found when zinc was fed, but not with added aluminum. The net retention of calcium from the basal ration was —0.63, while that from the high zinc ration was —1.66 gm. per day. Zinc likewise seriously affected phosphorus retention while aluminum caused only a slight decrease. On the high zinc ration net retention of phosphorus was —0.50 compared with —0.10 gm. per day for animals on the control ration. No significant differences were found in excretion rate from the blood, or the tract, nor in the endogenous fecal calcium or phosphorus fractions attributable to treatment. The slight depression in phosphorus retention attributable to aluminum and the much larger effect due to zinc appeared to be the result of absorption interference within the gastrointestinal tract. The significance of these values for the ruminant animal and the application of these procedures for quantitative mineral behavior studies were studied.

197. THE EFFECT OF VITAMIN AND TRACE MINERAL SUPPLEMENTATION ON WEIGHT GAINS OF FATTENING CATTLE. S. D. Formica, G. P. Andrews and F. Gordon Reiners, *Ultra-Life Laboratories, Inc.*

Five lots of 10 good quality feeder steers each, averaging approximately 770 lb., were placed in dry lot for a 117-day trial. Various vitamin and trace mineral additives to the basal ration were tested for their effect on daily gain and feed conversion. The basal ration consisted of ground shell corn, ground barley, mixed hay, corn silage, soybean meal, cottonseed meal, linseed meal, ground limestone, defl. rock phosphate, and cane molasses. The treatments were: basal; basal + fat soluble vitamins (A, D, and E); basal + water soluble vitamins (niacin, riboflavin, pantothenic acid, thiamine, and choline); basal + trace minerals (iron, manganese, copper, cobalt, iodine, and zinc); basal + fat soluble + water soluble vitamins + trace minerals. Daily gains for the respective treatments were: 2.47; 2.60; 2.55; 2.37; 2.84. Feed conversions (lb. feed/lb. gain, air dry basis) for the respective treatments were: 8.59; 8.13; 8.22; 8.46; 7.21. The basal + fat soluble and water soluble vitamins, respectively, stimulated gains slightly and gave better feed conversions. The basal + trace minerals somewhat depressed daily gains and had little effect on feed conversion. When the water soluble vitamins, fat soluble vitamins, and trace minerals were added to the basal ration as one treatment, daily gain was significantly higher and feed conversion significantly improved. This experiment indicates there may be inter-relationships between these micro-nutrients when combined which give increased gains and better feed utilization.

198. THE VALUE OF APPLE POMACE AS A ROUGHAGE FOR WINTERING BEEF CATTLE. Martin J. Burris and B. M. Priode, *Virginia Agricultural Experiment Station and USDA.*

Feeding trials were conducted at Front Royal, Virginia using apple pomace and locally grown silages for wintering beef cattle. In Trial 1, 20 open Shorthorn yearling heifers receiving dry apple pomace *ad lib.* and 1 lb. of cottonseed cake (CSC) were compared with a group of 25 open Shorthorn yearling heifers receiving sorgo-soybean sudan silage *ad lib.* and ¾ lb. of CSC for 106 days. Average gains were 115 lb. on pomace and 32 lb. on silage. Daily feed intake was 12.3 lb. pomace or 43.7 lb. silage. In Trial II apple pomace silage or alfalfa-barley silage was fed to two groups of 25 Angus cows for 117 days. Thirty-five lb. of silage and .75 lb. of CSC was fed daily for 30 days and 40 lb. of silage and 1 lb. of CSC was fed daily for 87 days. Average losses were 170 lb. on apple pomace silage and 184 lb. on mixed silage. In Trial III, two groups of Angus cows were fed as in Trial II except on alternate days 15 lb. of mixed hay was fed to replace the silage. Fifteen cows weighing 1024 lb. lost 147 lb. each on the apple pomace silage-hay ration, while 16 cows weighing 1017 lb. lost 136 lb. each on the mixed silage-hay ration. In Trial IV, two groups of Hereford cows were fed the same as in Trial III, except 5 lb. more silage was fed. Nineteen cows weighing 1155 lb. lost 46 lb. each on apple pomace silage-hay ration while 11 cows weighing 1194 lb. lost 218 lb. each on the mixed silage-hay ration. All cows calved during the feeding trial. Apple pomace supplemented with protein was a satisfactory feed for wintering cows and heifers on pasture aftermath.

199. PROGRESS REPORT ON A STUDY OF THE RESPONSE OF THE BOVINE TO A NATURAL RATION LOW IN COPPER. W. A. Hardison, R. F. Miller, N. O. Price, R. F. Kelly and G. C. Graf, *Virginia Agricultural Experiment Station.*

A long term project was initiated in December, 1955, to determine whether or not cattle subjected to a ration of grain products and protein supplements low in copper and forages containing borderline or low levels of copper can grow, reproduce, and produce satisfactorily. Male calves are included in the study for the purpose of obtaining data on the storage of copper in the liver and to relate liver copper levels with blood levels. The animals are fed a basal ration of whole milk to 60 days of age, a grain ration containing approximately 4 ppm Cu and forage averaging about 4 ppm Cu. Four treatment groups are maintained as follows: 1—basal plus Ca, P, Cu, Mn, Co, Zn, and Fe; 2—basal plus Ca, P, Mn, Co, Zn, and Fe; 3—basal plus Cu; 4—basal. All groups receive iodized salt. In groups 1 and 3, the animals are supplied with 9.5 ppm extra Cu until they are 4 mo. of age. Over 4 mo. of age the animals in these groups are supplemented with 19 ppm Cu. To date there has been no significant differences among groups with respect to weight gain or general appearance. Both the Cu-supplemented and Cu-deficient animals have made average daily gains of approximately 1.25 lb. The level of Cu in the blood and liver of male calves killed to date average, Group 1—0.48, 353; Group 2—0.41, 97; Group 3—0.51, 302; Group 4—0.32, 169 ppm.

200. BODY TEMPERATURE VARIATIONS IN DAIRY CATTLE DURING THE ESTRUS CYCLE AND PREGNANCY. T. R. Wrenn, Joel Bitman and J. F. Sykes, *Animal Husbandry Research Division, USDA.*

The success of basal temperature observations in determining ovulation time and confirming early pregnancy in the human has prompted a study of the fluctuations of body temperature during the estrus cycle and pregnancy in the bovine. Daily temperature observations were made in the late morning when the cows were at rest. The temperatures were taken vaginally with clinical thermometers at a depth of insertion

of between 8 and 9 inches. Twenty normal, cycling cows were followed for periods extending over 2 or more estrus cycles. Temperatures were found to be from 0.5° to 0.8° F. lower on the days immediately preceding heat than they were during mid-cycle. Daily temperature records were also kept on a group of pregnant cows. These in general had higher body temperatures than did non-pregnant cows. One to 3 days prior to calving a precipitous decline of about 1° F. was noted in all instances. Since progesterone is known to be a factor in temperature fluctuations during the human menstrual cycle this hormone was administered to 4 ovariectomized cows. Elevations of body temperature of 1° to 2° F. in the 2 to 4 day post-injection period resulted.

201. THE EFFECT OF HYPOTHALAMIC LESIONS ON MATING BEHAVIOR IN THE EWE. John A. Santolucito, M. T. Clegg and William F. Ganong, *University of California.*

Electrolytic lesions were placed stereotaxically in areas in or adjacent to the hypothalamus of 12 cycling ewes. Destruction limited to the massa intermedia or optic chiasma (3 animals) had no effect on cycles, but lesions in the ventral hypothalamus with a common area just above the median eminence, and anteriorly, abolished heat (9 animals). The histological appearance of the ovary, uterus, adrenal, and thyroid was studied in tissues obtained following necropsy. There were no changes in the adrenals and only slight changes in the thyroids of lesioned animals. In the ovaries of two of the animals in which heat was abolished, corpora lutea were found and in one other a mature follicle was observed. On the basis of the appearance of the epithelium, the uterine glands, and the amount of edema in the uterine mucosa, the uteri were classified as cyclic or acyclic. In only one animal (5825) was the uterus definitely anestrus. The pituitary content of FSH and LH was determined in all animals. As in the case of the uteri, in only one of the ewes (5825) in which cycles were abolished was the gonadotrophin level found to be abnormally low. In all others the level was not essentially different from the pituitary gonadotrophic content of the animals in which cycles continued. It is concluded that lesions in the anterior ventral hypothalamus abolish heat in cycling ewes without, at least in some cases, changing the cyclic release of pituitary gonadotrophins.

202. ESTROUS BEHAVIOR IN SPAYED COWS RECEIVING ESTRADIOL BENZOATE AND PROGESTERONE. J. M. Rakes, L. J. Hanka and R. M. Melampy, *Iowa State College.*

A group of three cows was injected subcutaneously daily with 0.4 mg. of estradiol benzoate from day 1 through 5; 0.8 mg. from day 5 through 10 over 1.6 mg. from day 10 through 15. Observations were made at 3 hour intervals of estrous response, vaginal temperature, mucous flow and vulvar response. Few periods of estrous behavior of short duration were observed in cows receiving 0.4 mg. of estrogen. Intervals of estrous activity became more frequent as the hormone level increased. Swelling of the vulva and the presence of mucus was observed. A second group of four cows was injected daily for 11 days with a conditioning level of estrogen and 1 mg. of progesterone. The average number of hours of bull acceptance was 64.5 with an average of 1 bull acceptance per cow every 2 days during the experimental period. The degree and duration of estrous response were greater when progesterone was given with estrogen (group 2) than in animals receiving estrogen alone (group 1). Vaginal temperatures were variable. In both groups of cows the udders became distended with milk. In determining conditioning levels of estrogen it was observed that diethylstilbestrol would produce similar estrous behavior in the same dosage range as estradiol benzoate. Four cows were subcutaneously injected with 3 mg. of estradiol benzoate which was 10 times the minimal level which would induce estrus. The average length of time of bull acceptance in these cows was 23 hours. Metestrous bleeding was not observed in any of the experimental animals.

203. THE EFFECT OF REPRODUCTIVE STAGE, AGE, AND DIETHYLSTILBESTROL ON THE PITUITARY GONADOTROPHIN CONTENT OF BEEF COWS. W. L. Reynolds, A. C. Warnick and M. Koger, *University of Florida.*

Pituitaries were obtained from two-year-old first service heifers, low fertility parous cows and low fertility cows fed 10 mg. of diethylstilbestrol daily. Animals were slaughtered at 3 days and 34 days after breeding. The pituitaries were frozen and later assayed for gonadotrophin activity using the male chick technique. The interval from estrus to slaughter had a highly significant influence on chick testes weight. Testes weight from chicks injected with pituitaries from 3-day cows was 24.1 mg. as compared to 31.6 mg. for 34-day cows and 26.4 mg. for cows not showing estrus. Total gonadotrophin content of pituitaries of heifers was 29.5 mg. compared to 27.7 mg. for low fertility cows and was not significant. There was a significant interaction between stilbestrol treatment and groups of animals. The average chick testes weight for control cows was 24.6 and 26.9 mg. and for stilbestrol fed animals 34.4 and 28.0 mg. at Belle Glade and Gainesville, respectively. There was a highly significant interaction between lactation and presence or absence of embryos with the average effect of embryos being non-significant.

204. INFLUENCE OF CERTAIN HORMONES ON ESTRUS, OVULATION AND FERTILITY DURING THE ANESTRUAL PERIOD OF THE EWE. J. F. Wagner, H. A. Henneman, J. E. Nellor and E. P. Reineke, *Michigan State University.*

Progesterone, PMS, estradiol and thyroprotein, alone and in various combinations, were administered to determine their effect on the reproductive physiology of the anestrous ewe. The ovarian status of ewes was standardized by using a macrocrystalline suspension of progesterone in 0.3% aqueous starch solution. Preliminary experiments in cycling ewes showed that a single injection of 280 mg. of this preparation prevents estrus and ovulation for 15–16 days. In anestrous ewes, where the above treatment will not induce heat, the greatest percentage showed estrus and ovulation when PMS was injected 16 days after progesterone. In ewes receiving progesterone and PMS, thyroprotein (0.2 mg. daily) had no effect on the occurrence of estrus or ovulation, although the onset of estrus appeared to be hastened. The addition of estradiol (200γ) to progesterone and PMS increased the occurrence of estrus from 44% to 88%. The incidence of ovulation (88%) was the same in ewes receiving progesterone-PMS or progesterone-PMS-estradiol. Regardless of the hormone combinations, pregnancy, as verified by autopsy 35 days post-service, was found only in ewes showing estrus for 24 hours or less. The overall conception rate was 27%.

205. THE EFFECTS OF GONADOTROPHIC HORMONE INJECTIONS ON INDUCTION OF ESTRUS IN LACTATING SOWS. A. D. Allen, J. F. Lasley and A. W. Uren, *University of Missouri.*

Sixty-four inbred Landrace, Poland and Duroc sows were used in an experiment conducted during the spring and fall of 1956 to determine the effectiveness of gonadotrophic hormone injections for inducing estrus in lactating sows. The sows were checked for estrus daily beginning 7 days after farrowing and until one post-weaning estrus period had occurred. Hormones were administered at a level of 1,000 I.U. per sow. All pigs were weaned at 56 days of age. Only one of twenty control sows came into estrus during lactation and this was on the 49th day. Estrus occurred in the remaining 19 sows an average of 9.6 days after the pigs were weaned. Eighteen sows were treated with gonadotrophins at approximately 20 days post partum, and three of these came into estrus 4 days following treatment. The remaining 15 sows failed to respond to treatment, but post-weaning estrus occurred in these at an average of 9.6 days. Twenty-six sows were treated at approximately 40 days post partum. Seventeen of these came into estrus at either 4 or 5 days following treatment but 9

failed to respond. The average interval from induced estrus to post-weaning estrus in these sows was 19.5 days, indicating that hormone injections initiated the estrus cycle. An average interval of 9.3 days was observed from weaning until estrus in these 17 sows, but this interval was only 5.6 days in the 9 sows in which estrus did not follow treatment.

206. THE INFLUENCE OF GROWTH HORMONE AND DIETHYLSTILBESTROL ON NITROGEN RETENTION IN LAMBS. Arthur Struempler and Wise Burroughs, *Iowa State College.*

Digestibility and nitrogen balance experiments were conducted in studying the influence of growth hormone and stilbestrol administrations in wether lambs. The lambs received rations containing either high or low levels of protein and rations containing either low or high levels of energy intake. Regardless of the level of energy intake, or the level of protein in the ration, either growth hormone or stilbestrol when administered singly resulted in increased nitrogen retention. When growth hormone was given to lambs already receiving stilbestrol, very little increase in nitrogen retention occurred over that resulting from the stilbestrol alone. Lambs receiving the higher level of energy intake, under all conditions, retained more nitrogen than those receiving the lower level of energy intake. Neither dry matter nor protein digestibility were affected by either growth hormone or stilbestrol treatment. These observations are suggestive that stilbestrol increases nitrogen retention in ruminants through the increased release of growth hormone in the animal body.

207. HISTOLOGICAL STRUCTURE AND PROGESTERONE CONTENT OF SWINE CORPORA LUTEA AS AFFECTED BY EXOGENOUS PROGESTERONE. H. G. Spies, H. L. Self and L. E. Casida, *University of Wisconsin.*

Twenty-seven bred gilts were divided into eight experimental groups. Groups I, II and III were killed on the 18th day of gestation and all other groups on day 25. Groups I and IV were untreated controls; the remaining groups were injected subcutaneously in the flank with 1 mg. of progesterone per lb. body weight (25 mg. per cc corn oil). Group II received injections from day 4 to day 18 after breeding; group III from day 0 to day 18; group V from 0 to 4; group VI from 4 to 18; group VII from 4 to 25; group VIII from 18 to 25. One random corpus luteum from each gilt was used for histological determination of the proportion of "functional" lutein cells, while the remainder were assayed chemically for progesterone by a method involving column chromatography and counter current distribution. There was a correlation of .83 between progesterone concentration and the proportion of "functional" cells calculated between individuals within groups ($P<.01$); and a correlation of .76 between the various groups ($P<.05$). Average weight of the corpora lutea was found to be more important than the number of corpora lutea in linear effect on total tissue weight, progesterone concentration, and total progesterone. Their relative magnitudes for the three dependent variables were 1.7, 6.2 and 3.0, respectively. Progesterone concentration was more important than total tissue weight in depicting total progesterone (standard partial regression of .93 vs. .53), and cell type more important than average corpora lutea weight for progesterone concentration (.65 vs. .24).

208. THE EFFECT OF HIGH LEVELS OF EXOGENOUS PROGESTERONE ON THE CORPUS LUTEUM OF THE EWE. R. G. Zimbelman and L. E. Casida, *University of Wisconsin.*

The effect of high levels of exogenous progesterone on the corpora lutea was studied for various intervals on 60 mated ewes. Crystalline progesterone, 25 mg. per ml. of corn oil, was given in subcutaneous injections once daily at the rate of 2 mg. per

5 lb. body weight. Ewes receiving progesterone injections beginning one day following the onset of estrus yielded lighter corpora lutea at 13 days than comparable control ewes whether the injections ceased at 5 days or 13 days (635 vs. 424, 324 mg.). Corpora lutea from ewes receiving progesterone injections from day 5 until day 13 were lighter (525 vs. 635 mg.) than the controls, but the difference was not statistically significant. Injections from days 5 to 25 caused a decrease in corpora lutea weight (450 vs. 638, 641, and 702 mg.) as compared respectively to injections from days 5 to 13, or from days 13 to 25, or to the 25 day controls. The latter three groups were not significantly different from each other. Withdrawal of progesterone at the 13th day did not interfere with the maintenance of pregnancy to the 25th day. Histological study failed to indicate an effect of progesterone on the luteal cells, except that the group treated from days 1 to 13 had fewer of the mature active type cells when studied at 13 days.

209. THE EFFECT OF LEVEL OF FEEDING AND PROGESTERONE INJECTIONS ON REPRODUCTIVE PERFORMANCE IN GILTS. C. E. Haines, A. C. Warnick, H. D. Wallace and G. M. Edwards, *University of Florida.*

Eighty-five gilts, weighing approximately 100 lb., were full fed a growing ration until their second estrus. All gilts were bred at second estrus and one-half of them continued on the same ration, while the other half were placed on a ration providing 50% of the energy (limited fed) of the full fed ration. All gilts were fed equal quantities of protein, vitamins and minerals and kept on pasture. One-half of the gilts on each ration were given 25 mg. of progesterone every other day during the first 25 days of gestation. One-third of each sub-group was slaughtered 25 days post-breeding, one-third 40 days after breeding and the remainder allowed to farrow. The number of normal embryos at slaughter, and pigs born alive were compared between rations (full vs. limited) and hormone treatment (progesterone vs. no progesterone). Neither ration nor hormone treatment had a significant influence on the number of embryos present at slaughter or live pigs. However, the stage of gestation showed a significant influence on the number of embryos and live pigs. At 25 days, 40 days and term, there were 11.8, 10.0 and 6.9 embryos and pigs, respectively. Embryonic survival rates at 25 and 40 days were 81.7 and 76.1% respectively. Differences in embryonic survival due to stage of gestation, ration and harmone treatment were not significant. Therefore, 25 mg. of progesterone every other day during the first 25 days of gestation did not reduce embryonic mortality.

210. THE EFFECT OF FLUSHING FOR VARIOUS LENGTHS OF TIME ON THE OVULATION RATE OF CHESTER WHITE AND CHESTER WHITE-POLAND CHINA CROSSBRED GILTS. D. R. Zimmerman, H. L. Self and L. E. Casida, *University of Wisconsin.*

Thirty-two Chester White-Poland China crossbred (XB) and 16 Chester White (CW) gilts were used. The nutrient intake of all gilts was limited until puberty by *ad libitum* feeding a 13.3% fiber ration. Gilts of each breeding group were randomly assigned to four experimental treatments as they attained puberty. Treatment A (control) was not flushed; treatments B, C, and D were flushed (self-fed a fattening, 5.9% fiber ration) beginning on the 8th, 12th and 16th day respectively of the first estrual cycle. All gilts were slaughtered three to five days after their second estrus and first and second heat ovulation rates were determined. Average increases in ovulation rate from the first to second estrus for treatments A, B, C, and D were 1.4, 2.6, 2.5 and 6 ova respectively for the XB gilts and 1.5, 3.2, 4.5 and 4.5 ova respectively for the CW gilts. The increases in ovulation rate from treatments C and D over both breeding groups were significantly greater ($P<.02$) than A while the

increase of treatment B approached being significantly greater ($P<.07$). Such individual characteristics of the gilts as preflush and postflush weight and backfat thickness as well as average daily gain and feed consumption during the flushing period were not significantly associated with increase in ovulation rate.

211. SOME EFFECTS OF LEVEL OF FEEDING ON OVULATION RATE IN YEARLING EWES. W. C. Foote, A. L. Pope, A. B. Chapman and L. E. CASIDA, *University of Wisconsin.*

A two year study involving 273 short yearling ewes of different breeding (117 of mixed breeding, 1955, and 86 grade Hampshire and 70 grade Columbias, 1956) were divided each year into three groups and fed as follows until they were bred in October (a period of 8–9 months): (1) hay plus grain for entire period, (2) hay only for entire period except approximately three weeks before breeding when they were flushed with grain and (3 hay only for entire period. The percent of the ewes with multiple ovulations for the three different feeding regimens for each breed-year group were as follows: 1955, 46, 29, 14; 1956 Hampshire 79, 28, 31; 1956 Columbias 61, 29, 29. Overall averages were 62, 28, 25. Significant differences from the straight hay fed group were shown only by the hay plus grain. Standard partial regressions (path coefficients) were calculated within each feed group to show the importance of preflush body weight (143, 102, 103 lb. av. resp.) and average daily gain during the "flushing" or comparable periods for the straight fed groups (.04, .20, .07 lb. resp.) as sources of variation in ovulation rate. The paths from ovulation rate to preflush body weight for the different feed groups were similar and significant (+.29, +.29, +.25). The paths from ovulation rate to average daily gain were negligible. Removal of variation in ovulation rate due to preflush body weight by use of the simple, pooled within feed group regression also removed the differences due to feeding.

212. THE EFFECT OF DIFFERENT COMBINATIONS OF ENERGY AND PROTEIN ON THE OCCURRENCE OF ESTRUS, LENGTH OF THE ESTROUS PERIOD, AND TIME OF OVULATION IN BEEF HEIFERS. J. N. Wiltbank, A. C. Cook, R. E. Davis and E. J. Warwick, *USDA, Agr. Research Service.*

Fifty-four Angus heifer calves averaging 391 lb. were divided into 9 lots. Three lots (I, II and III) were full fed, three (IV, V and VI) received approximately two-thirds of the full fed lots, and 3 lots (VII, VIII and IX) were fed at a level calculated to maintain weight. Within each energy level one lot received 0.23 lb. digestible protein per cwt. (I, IV and VII); one received 0.15 lb. digestible protein per cwt. (II, V and VIII) and one received 0.06 lb. digestible protein per cwt. (III, VI and IX). All rations were pelleted and heifers receiving limited amounts of energy were fed individually. The average daily gains for 250 days for lots I thru IX were: 1.54 lb., 1.38 lb., 0.29 lb., 0.77 lb., 0.92 lb., 0.30 lb., 0.04 lb., 0.15 lb., and 0.11 lb., respectively. The percentages of heifers showing estrus during the first 250 days on feed for lots I thru IX were 100, 100, 67, 100, 100, 67, 50, 83, and 33, respectively. The average time from beginning of the experiment to first estrus (assuming the date of first estrus to be 250 days from beginning of experiment for heifers which have not shown estrus) is 100, 82, 193, 148, 127, 203, 207, 186, and 215 days, respectively. Among heifers showing heat, a correlation of −0.39 was observed between the number of days from beginning of the experiment to first heat and average daily gain during that period. During a three week period checks for estrus and ovulation were carried out at 2 hour intervals. The average length of 45 estrous periods was 21.1 hours. There was no difference between lots. The average time from end of estrus to ovulation was 9.2 hours.

213. URINARY MINERAL AND NITROGEN EXCRETION RATES AS ASSOCIATED WITH PREGNANCY, MAINTAINED WITH PROGESTERONE, AND LIMITED DIET FEEDING. K. A. Kendall and R. L. Hays, *University of Illinois.*

Three groups of five mated female rats each, on the day of mating, were placed on a diet of sucrose and distilled water. Groups 1, 2 and 3 respectively received: no treatment, 5 mg. progesterone per animal daily and 4–6 I.U. of prolactin per animal daily. Urine from each animal was collected individually during 7 consecutive 3-day periods. Pregnancy was maintained in 40%, 100% and 80% of the females, respectively, for groups 1, 2, and 3. The 3-day urine collections were analyzed individually for calcium, inorganic phosphorus and total nitrogen. Average calcium to phosphorus excretion ratios, respectively, for the entire period for groups 1, 2 and 3 were: 1:2.96; 1:5.44; and 1:3.74, while the average calcium to nitrogen excretion ratios in the same order were: 1:45; 1:74; and 1:50. Phosphorus to nitrogen excretion ratios showed much less variation, ranging from 1:13.3 for group 3 to 1:15.2 for group 1. The greatest difference in ratios occurred between the pregnant, progesterone-treated group and the non-pregnant females from groups 1 and 3. These results seem to indicate that progesterone played a role in mineral and nitrogen metabolism.

214. THE ANABOLIC RESPONSE TO LOW LEVELS OF ESTROGEN AS INDICATED BY THE EFFECT ON THE MOUSE *LEVATOR ANI* MUSCLE. M. T. Clegg and R. L. Gaskell, *University of California.*

Low levels of estrogen (17β estradiol propionate) produced a significant increase in the weight of the *levator ani* muscle of castrate male mice. A dose response relationship between the level of estrogen injected and the weight of the muscle was found within the range of .38 to 50 mcg. The maximum response obtained was about 100% greater than the control weight. On the other hand the maximum response to testosterone stimulation is about 200% greater than unstimulated controls. In addition to the weight of the *levator ani,* weights of the seminal vesicles, preputials, and ventral prostates were obtained at necropsy. The higher levels of estrogen (10 to 500 mcg.) produced a slight, but significant, increase (2-fold) in the weight of the seminal vesicle. Weights of the ventral prostate and preputial gland were not influenced by estrogen treatment. The amount of testosterone required to produce a 100% increase in weight of *levator ani* muscle resulted in a 5-fold increase in seminal vesicle weight and a 7-fold increase in ventral prostate weight indicating that the responsivity of the *levator ani* is not necessarily dependent on an androgenic effect. The addition of estrogen to low levels of testosterone (10 to 50 mcg.) produced a greater response than the same level of testosterone alone on the weight of the *levator ani.* On the other hand the addition of estrogen to high levels of testosterone produced no greater response on this organ than testosterone (50 to 300 mcg.) alone.

215. EVIDENCE FOR A COMPLEX BLOOD GROUP SYSTEM IN SHEEP RELATED TO THE B SYSTEM IN CATTLE. B. A. Rasmusen, Y. Suzuki and C. Stormont, *University of California.*

Over 50 reagents have been developed at the School of Veterinary Medicine, University of California, for blood typing sheep. Of these, 25 or almost one-half, react in the complex B system. Nine of these reagents were prepared from bovine isoimmune sera (see Stormont *et al.,* these meetings). Eleven were prepared from ovine isoimmune sera, and five from ovine anti-cattle sera. We have evidence for at least 25 alleles controlling phenogroups in the B system of sheep: 13 in Suffolks, 12 in Shropshires, 6 in Corriedales and 5 in Targhees. A few B alleles have been found in more than one breed. Few data are as yet available for other breeds. The B system of cattle includes at least 165 alleles, and it is expected that further study will reveal many more alleles in the B system of sheep. Differences in breeds are discussed.

216. CROSS REACTIONS OF OVINE AND BOVINE ISOIMMUNE ANTIBODIES IN CATTLE AND SHEEP BLOOD-TYPING STUDIES. Clyde Stormont, Yoshiko Suzuki and B. A. Rasmusen, *University of California.*

Normal sheep sera rarely contain hemolysins for cattle. In contrast, we have observed that 29 of 47 ovine isoimmune sera do. The cross reactions of 20 of these 29 antisera have been analyzed. One of these antisera cross reacts in the F-V system where it parallels the reactions of bovine anti-F. Another reacts in the C system where it parallels anti-R. The remaining 18 cross react exclusively with phenogroups in the complex B system of cattle. Some of the antibodies cross reacting in the B system parallel the reactions obtained with our cattle I, E'_3 and NF6 reagents but the majority have specificities which are new. Some produce dosage reactions which are of considerable use in phenogrouping in the cattle B system. On the basis of such cross reactions alone, it can be assumed that sheep have blood group systems related in genetic derivation to B, C and F-V of cattle. On the other hand, the normal sera of most cattle contain natural hemolysins for sheep, and some of these react with the red cells of all sheep. Nevertheless, by making selective absorptions on bovine isoimmune sera with the red cells of individual sheep, it is possible to prepare reagents which detect individual differences in sheep. Nine of 10 reagents so prepared appear to react exclusively with phenogroups in a blood group system of sheep which is related to the B system of cattle (see Rasmusen *et al.*, these meetings). Both reciprocal and nonreciprocal cross reactions are observed.

217. RELATIONSHIPS BETWEEN CONCENTRATE FEEDING AND THE OCCURRENCE OF URINARY CALCULI. Robert H. Udall and Roberta Hartman, *Colorado State University, Fort Collins.*

Two approaches were applied to the problem of concentrate feeding and urinary calculi. In the first a factorial arrangement of corn vs. milo, males vs. females, and 10% salt vs. no salt was made in a randomized trial using 100 lambs. Based on the occurrence of renal calculi there was no difference between males and females nor between the corn and milo. Based on deaths and bladder calculi there was a significantly greater occurence in the milo-no salt group. There were no deaths or renal calculi in the salt fed groups. The second phase was a study of the effect of feeding milo on the mucoprotein and mucopolysaccharide complex in the urine, which appears to be associated as a ground substance promoting the deposition of mineral. Six lambs were used, consecutive 24-hour urine collections made, and the ration shifted daily by a fixed increment from alfalfa to milo. The proteins of the urine were precipitated with perchloric and phosphotungstic acids, and nitrogen and hexosamine determined. With the increase in the level of concentrates in the ration, the protein nitrogen of the muco-complex appeared to remain unchanged but the hexosamine increased. This pattern suggests that an increased urinary output of mucopolysaccharides results from a dietary metabolic interaction and becomes associated with proteins present in the urine to form a complex actively promoting mineral deposition.

218. THE EFFECT OF VARYING PROTEIN INTAKE ON BLOOD COMPOSITION, REPRODUCTION AND GAINS IN TWO-YEAR-OLD HEREFORD HEIFERS. E. Bedrak, A. C. Warnick, J. F. Hentges, Jr. and T. J. Cunha, *University of Florida.*

Twenty, two-year-old heifers averaging 666 lb. were divided into four groups and were individually fed the following rations containing different levels of protein with equivalent amounts of energy, vitamins and minerals: Group I, Control, recommended N.R.C. level of digestible protein; Group II, 77%; Group III, 56%; and Group IV, 46% of the protein in the control ration. Weights and blood samples were taken at 28-day intervals; while rectal palpations of the ovaries were made every

14 days. All heifers had active ovaries prior to experiment as shown by a corpus luteum. All heifers except one in Group IV were cycling regularly during the first 140 days of the experiment. After 140 days on the above rations the average R.B.C. values were 6.36, 6.42, 5.90 and 5.85 million cells/cmm. for Group I through IV respectively. Average W.B.C. counts were 7,880, 8,096, 6,632 and 8,112/cmm. for the respective groups. Average hemoglobin values were 11.71, 12.64, 11.22 and 10.72% for Group I through IV respectively. Hematocrit values were 38.56, 40.79, 37.96 and 34.72% for the respective groups. Serum protein values were 7.72, 7.98, 7.10 and 7.14% for Group I through IV respectively. The average blood volume values after 154 days on experiment were 5.07, 4.66, 4.50 and 4.80% for the respective groups. The total gains which were statistically significant for the 140-day period were: 125.0, 96.8 and 1.8 lb. per animal for Group I, II and III respectively, while Group IV lost 34.6 lb. per animal.

219. EFFECTS OF SHEARING DATE ON EWE PERFORMANCE. E. P. Warren, R. S. Lowrey, Jr., J. H. Maner, J. R. Danion and J. L. Carmon, *University of Georgia.*

A total of 188 annual performance records were collected over a four year period (1952–55) on a flock of grade Hampshire ewes. Thirty-five to fifty-eight ewes were represented each year. Original ewes were allotted at random to the treatment groups and remained in their respective groups for the duration of the experiment. Group I (Early shorn) was shorn approximately April 7 and Group II (Late shorn) was shorn approximately May 21 each year. Replacement ewes were assigned to the treatment opposite their dams. The two groups of ewes were exposed to the same rams during unlimited breeding seasons which began about July 1. The 1954 season was an exception in that the rams were removed on October 1 of that year. Average percentages of ewes lambing during the four years were 73% and 86% ($P<0.10$) for early and late shorn ewes, respectively. Comparable values for the 1954 season only were 27% and 63%, respectively. Four year averages for number of lambs dropped per 100 ewes lambing were 118 and 134 ($P<0.10$) for early and late shorn ewes, respectively. In 1954 early shorn ewes dropped 100 lambs and late shorn ewes 141 lambs per 100 ewes lambing. Average lambing date over the four years was somewhat earlier (7.0 days) for the late shorn ewes. This difference was not significant. Shearing date had no effect on average date of first estrus nor average fleece weight.

220. FACTORS INFLUENCING THE REVERSIBLE INHIBITION OF SPERMATOZOAN METABOLISM BY CO_2. G. W. Salisbury, *University of Illinois.*

The discovery of the reversible inhibition of motility by CO_2 and maintenance of fertility of CO_2-inhibited bovine sperm cells by VanDemark and Sharma and the discovery of the reversible nature of the metabolic function by Salisbury and Van Demark have focused attention on this method of sperm cell preservation. While the key to inhibition of metabolism rests in anaerobiosis and relatively high tensions of CO_2 in the gas phase a number of supplementary factors aiding in the inhibition have been found. By inclusion of some of these in the medium the level of CO_2 in the gas phase at which inhibition and reversal are maximized may differ widely. These factors include as the more important, pH, the level of the K cation in relation to Na, the bicarbonate anion, the presence of sulfanilamide or an inhibitor of carbonic anhydrase, and unidentified factors in the semen itself.

221. PROBLEMS INVOLVED IN STORING SEMEN IN THE ILLINI VARIABLE TEMPERATURE DILUENT. N. L. VanDemark, *University of Illinois.*

The use of CO_2 in storing semen in sealed ampules at room temperatures in the Illini Variable Temperature (IVT) diluent has opened a new concept of semen preser-

vation. With the attempts to put this concept into practice have come problems involving optimal constituents and handling procedures. In the procedure as originally described (J. Dairy Sci. 40:438, 1957) the diluent was saturated by bubbling CO_2 through the buffer portion. The loss of CO_2 was prevented by sealing the diluted semen in ampules. Laboratory tests have now shown that sperm survival was best when the volume of diluted semen was equal to or greater than the volume of the gas space in the sealed ampules. Each increase in gas volume above the volume of diluted semen resulted in shorter sperm survival. The addition of catalase at the rate of 100 μg. per ml. of diluted semen increased sperm survival and eliminated much of the harmful effect of increased gas volumes. Variations in the interval from filling the ampules to sealing from one minute to two hours had little effect on sperm survival. Increasing the amount of egg yolk, glucose and KCl over that in the originally described diluent brought about increases in the survival time of the sperm. Decreasing temperature from 80° C. to 60° or 40° C. greatly improved sperm survival, but increasing the temperature to 100° C. greatly shortened sperm life. An interaction between the levels of constituents in the diluent and storage temperature seemed apparent.

222. THE EFFECT OF FSH AND ESTRADIOL BENZOATE ON INDUCED ESTRUS IN GILTS. B. N. Day, L. N. Hazel, L. L. Anderson and R. M. Melampy, *Iowa State College.*

Estradiol benzoate and follicle stimulating hormone (Armour Gonadotropin) were administered to 16 sexually mature gilts in the luteal or early follicular stage of the estrous cycle to induce ovulation and boar acceptance. The hormones were injected intramuscularly and FSH was administered twenty-four hours prior to estrogen. All animals received 40 Armour Units of FSH whereas the dosage of estradiol benzoate ranged between 5 and 80 mg. A group of twelve gilts was injected between the 7th and 15th day of the estrous cycle. Eleven of these animals failed to show boar acceptance although a response to the treatment was indicated in the form of restlessness and mounting behavior. The one gilt bred following injection in the luteal phase showed heat 2.5 days after receiving FSH followed by 30 mg. of the estrogen. Examination of the reproductive tract of this gilt revealed 10 ovulation sites but recovery of ova was unsuccessful because of a large amount of debris within the cornua. A group of four gilts was injected with FSH and 30 mg. of estradiol benzoate 15 to 17 days following the onset of estrus. Three of these showed induced heat. Twenty-eight ova were recovered from two of the reproductive tracts from this group and the average fertilization rate was found to be 75%. Induced ovulations occurred following hormone administration either in the follicular or luteal phase of the cycle whereas boar acceptance was largely determined by the time of injection in the cycle. (Acknowledgement is made of support by Armour and Co., Inc.).

223. CHANGES IN THE BLOOD SERUM PROTEINS IN THE DAIRY CALF AND ITS DAM AND IN THE WHEY PROTEINS OF THE MAMMARY SECRETIONS DURING THE FIRST WEEK AFTER PARTURITION. F. D. Hill, R. S. Allen and N. L. Jacobson, *Iowa State College.*

Samples of venous blood were taken from six cows (5 Holsteins, 1 Brown Swiss) and their calves and of mammary secretions from the dams at parturition and at 1, 2, 3, 4, and 6 days thereafter. Serum and whey proteins were subjected to paper electrophoresis (veronal buffer, pH 8.6; μ=0.1; 500 volts; 5 hours) and dyed with bromophenol blue. The percentages of α-, β- and γ-globulins and albumin in the serum and of the whey "immune" globulin, with essentially the same mobility as the serum γ-globulin, were estimated (densitometer) from the paper strips. Total protein values for the serum and whey samples were determined. Although there were no marked

changes in the percentage of any serum protein fraction in the dams during the 6-day period, albumins decreased slightly, while the α- and γ-globulins increased somewhat. Calf serum γ-globulin levels increased markedly during the first day, somewhat less during the second day, and slowly thereafter; albumin and α-globulin decreased significantly during the first day, then slowly increased; β-globulin decreased slightly during the first day, then slowly increased. The percentage(s) (as percent of total serum protein) of γ-globulin increased markedly during the first day, whereas those for albumin and α-globulin decreased; thereafter the percentages of these proteins were essentially constant. Mammary secretion "immune" globulin decreased markedly, both percentage-wise and quantitatively, during the first two days and slowly thereafter.

224. THE ESTIMATION OF HIGHER FATTY ACIDS FORMED *IN VITRO* BY RUMEN MICROORGANISMS. R. P. King and Wise Burroughs, *Iowa State College.*

More than 95% of the total fatty acid production by microorganisms in the rumen of cattle and sheep is a mixture of acetic, propionic, and butyric acids. Little is known relative to longer carbon-chain fatty acids produced in the rumen with respect to their specific quantitative relations and significance in ruminant metabolism. A partition chromatographic method employing buffered silicic acid and chloroform-butanol mixtures was developed in quantitatively measuring straight-chain fatty acids containing six or more carbon atoms. Preliminary usage of the method showed measurable amounts of these higher fatty acids to be approximately 1.5% of the total fatty acids present. Subsequently, an artificial rumen technique using washed cell suspensions was employed in studying the influence of various carbohydrate sources upon the quantitative production of these higher fatty acids. The various carbohydrate sources produced different amounts of long chain fatty acids which are believed to have significance in ruminant nutrition.

225. ESTROGEN EXCRETION BY COWS. J. M. Rakes, J. W. Gurland and R. M. Melampy, *Iowa State College.*

Three spayed cows were fed .10 mg. of diethylstilbestrol daily for a period of 8 days and then were given 100 mg. daily for a similar period. On the sixth day of administration each cow was placed in a metabolism stall where the urine and feces were collected for 3 days. The method of assay used was uterine response of immature female mice (8–10 gm.). Urine and dried feces were added directly to the rations. Animals were fed *ad libitum* for 6 days with each cage receiving the same amount of feed. Relative potency estimates were established using the indirect 4-point assay. Results obtained indicated that 62.7% of the estrogenic activity fed to the cow was detected in the urine and feces on the 10 mg. level with 76.4% in the feces and 32.6% in the urine. On the 100 mg. level 61.1% of the total estrogenic activity fed was detected with 65.3% in the feces and 34.7% in the urine. Urine and feces samples from intact cows in proestrum were assayed with an average uterine weight of 12.3 mg. for urine and 10.3 mg. for feces; whereas the average control uterine weight was 7.2 mg. Assays indicated small amounts of estrogen in milk from pregnant cows with smaller quanities in milk from non-pregnant cows. The feeding of 10 mg. of diethylstilbestrol did not increase the estrogenic activity in the milk. A cow was fed 1 mg. of diethylstilbestrol for 8 days, slaughtered, and bile samples were taken. The sample assayed contained 6.3% of the activity fed.

226. FACTORS CONCERNED IN THE COMPARATIVE HEAT TOLERANCE OF JERSEY, HOLSTEIN AND RED SINDHI-HOLSTEIN (F_1) CATTLE. J. E. Johnston, F. B. Hamblin and G. T. Schrader, *Louisiana Agricultural Experiment Station.*

Studies were conducted to compare lactating and non-lactating Jersey, Holstein and Red Sindhi-Holstein (F_1) cattle under varying conditions of thermal stress. Four

non-lactating animals of each breed were compared under natural summer climatic conditions and three lactating animals of each breed were compared in the climatic control chamber under cool (70° F.) to hot (95° F.) conditions. The total heat production and heat production per unit of surface area of non-lactating Red Sindhi-Holstein crossbreds were shown to be lower than those of Jerseys and Holsteins. The principal difference in heat balance between lactating Red Sindhi-Holsteins and the European breeds was in heat production rather than heat loss. These differences appeared to be associated with resting heat production rather than with the increment of heat associated with FCM produced which was estimated to be 10, 13 and 10 kcal. per hr. per lb. for Jerseys, Holsteins and Red Sindhi-Holstein crossbreds respectively. Exposure to elevated temperatures and humidities resulted in initial increases in heat production apparently due to elevated body temperatures and respiratory activity among the Jersey and Holstein cows. Red Sindhi-Holsteins did not show a marked initial rise in heat production or body temperature. All animals showed a decrease in heat production apparently due to adaptation during the last period of study even though air temperature and humidities were elevated further. Serum protein bound iodine levels paralleled changes in heat production suggesting that the thyroid gland may have been involved in adaptation.

227. THE INFLUENCE OF GLYCEROL AND VARIOUS DILUENTS ON LOW TEMPERATURE SURVIVAL OF RAM SPERMATOZOA. N. L. First, H. A. Henneman and James A. Williams, *Michigan State University*.

Thirty-five split ejaculates of ram spermatozoa were used to determine the effect of the following factors on sperm survival after freezing and storage at —79° C.: (1) levels of glycerol (2) addition of arabinose (3) milk extender and (4) yolk phosphate citrate extender containing various levels of egg yolk. An analysis of variance, applied to percent survival data, indicated the following significant results: the survival of frozen ram sperm in a milk diluter containing 0, 2, 4, 6, 8, 10, 12 or 15% glycerol was curvilinear with the greatest survival at 6% and 8%. The addition of 1.25% arabinose improved sperm survival in both milk and egg yolk phosphate citrate extenders. There was no significant difference between egg yolk levels of 50, 37.5 or 30%. Frozen ram semen diluted with milk, 7% glycerol and 1.25% arabinose was compared with the insemination of .2 ml. of freshly collected undiluted semen, in a breeding trial involving first service to 23 Hampshire ewes. Of 12 ewes bred with frozen ram semen 17% lambed with a 33% lamb crop, whereas 64% of 11 control ewes lambed with a 109% lamb crop.

228. A STUDY OF FETAL HEMOGLOBIN IN CALVES. R. M. GRIMES, C. W. Duncan and C. A. Lassiter, *Michigan State University*.

The postnatal persistence of fetal hemoglobin and its relation to hemoglobin F, which was previously found to occur with hemoglobin A in some mature Guernseys and Jerseys and alone in others, were investigated by electrophoretic methods. At birth, fetal hemoglobin made up 41 to 100% (average, 87%) of the total hemoglobin of 23 calves. In preparations from 14 bull calves, fetal hemoglobin diminished rapidly and disappeared entirely from paper electrophoretic patterns at an average age of 65 days (range, 55 to 73). With four heifer calves, the average age at which it was no longer detectable was 97 days (range, 54 to 124). In three male calves (2 Guernseys and one Brown Swiss), the ratio of hemoglobin A to fetal hemoglobin approached 1.0, the ratio found in all mature cattle possessing both hemoglobins A and F, and remained at this level. In two calves (Jersey and Guernsey bulls), no hemoglobin A appeared in the blood from birth to 67 and 83 days of age, respectively. With the conditions used (barbital buffer pH 9.0, ionic strength 0.1, 10 ma. applied to eight Whatman 3 MM paper strips for 16 hours at 4° C.), fetal hemoglobin migrated

3.8±0.31 and hemoglobin F 3.9±0.14 cm. toward the anode. The difference is not statistically significant. Comparisons between classical electrophoretic patterns of globins prepared from the hemoglobin F of a cow and from the hemoglobin (87% fetal) of a calf were made at three pH levels. Only insignificant differences in mobilities and proportions of components were found. The evidence suggests that hemoglobin F may be identical to the fetal hemoglobin.

229. SOME PHYSIOLOGICAL EFFECTS OF SHEARING VS. TAGGING EWES AT BREEDING TIME. Hugh E. Henderson and H. A. Henneman, *Michigan State University.*

A total of 265 purebred Hampshire and Shropshire ewes were used in a 4-year study (1954–1957) to determine the effects of shearing vs. tagging at breeding time on the subsequent lamb crop. Both breeds were divided between the shorn and tagged groups and alternated between groups for each of the four years. All ewes were shorn in March and either shorn or tagged at the beginning of a three-week flushing period prior to exposure to the ram. The shorn group showed an average increase of .18* lambs born (1.56 vs. 1.38) and .27** lambs weaned (1.32 vs. 1.05) per ewe exposed over the tagged group. No apparent difference existed in the average amount of wool shorn annually (7.92 vs. 7.79) for the shorn and tagged groups. The first two years data, when ewes were bred for January lambs, showed that the shorn group lambed on an average of 25.54** days earlier (February 4 vs. March 2) than the tagged group. One year's data (1957) involving 24 of the Hampshire ewes showed the following differences during the 3-week flushing period for the shorn and tagged groups respectively: (a) 17.29% and 16.46% 4-day uptake of radioactive I^{131} by the thyroid, (b) .15 mg. and .10 mg. of l-thyroxine secreted daily by the thyroid as measured by radioactive I^{131} techniques, (c) 103.0° ** and 103.4° fahrenheit rectal body temperature, and (d) 12.1* and 9.4 lb. gain in body weight.

230. FURTHER STUDIES OF THE BOVINE DIGESTIVE TRACT USING A DUODENAL FISTULA TECHNIQUE. A. Dare McGilliard, C. W. Duncan and C. F. Huffman, *Michigan State University.*

A Holstein steer with a re-entrant duodenal fistula has been used to partition digestion and passage in the alimentary tract into that attributable to the stomach, to the lower gut and to the total tract. The following rations were fed at comparable levels of dry matter intake: 1—100% corn, 2—70% corn + 30% alfalfa hay, 3—70% alfalfa hay + 30% corn, 4—100% alfalfa hay. Chromic oxide ratios were used as an expedient method of determining total digestibility and composite samples of duodenal ingesta taken continuously at hourly intervals for 24 hours *post cenam* were used to determine digestibility in the stomach. Lower gut digestibilities were determined by difference. The data indicate that considerable amounts of ash and ether extract were added to the ingesta during its passage through the stomach and that the major portions of these two fractions were absorbed in the lower gut. Protein, calculated as $N \times 6.25$, was similarly added in the upper tract but in decreasing amounts as the rations fed went from all corn towards all hay. Only in the case of the all hay ration had protein been removed in the upper tract. Fiber digestibility was negligible for both rations where corn was the major constituent but appeared normal for rations high in hay. Little or no fiber digestibility occurred in the lower gut with any of the rations. The digestibility coefficients for organic matter in the upper tract, expressed as the percent of total digestibility, were 73.5, 58.0, 58.1 and 68.4% for rations 1, 2, 3 and 4, respectively.

* $P<0.05$; ** $P<0.01$.

231. BLOOD FAT LEVELS AND CARCASS CHARACTERISTICS AS INFLUENCED BY THIOURACIL FEEDING AND ENVIRONMENTAL TEMPERATURES IN SWINE. R. E. Morrow, A. M. Pearson, E. P. Reineke and R. J. Deans, *Michigan State University.*

Blood fat levels and carcass characteristics of thiouracil fed and control pigs were compared at environmental temperatures of 40° and 80° F. Pigs treated with thiouracil showed considerably higher blood fat levels than control pigs at both temperatures. Control pigs held at 40° F. showed higher blood fat levels than control pigs held at 80° F. Thiouracil decreased rate of gain at 40° F. but not at 80° F. Thiouracil treated pigs at 80° F. gave the highest economy of feed utilization but there was little difference from controls at the lower temperature. Pigs held at 80° F. had thicker backfat than pigs held at 40° F. Primal cuts on both carcass and live bases were greater in treated pigs than in controls and greater at 40° F. than at 80° F. The pigs maintained at 40° F. yielded a higher percentage of lean cuts on both carcass and live bases and a lower percentage of fat trim than those held at 80° F. Livers were larger in thiouracil-fed pigs at both temperatures than in controls but the difference was greater at the higher temperature. Thyroids were larger in thiouracil-fed than in control animals. The heights of thyroid acinar cells in pigs held at 40° F. were significantly greater than from pigs at 80° F., indicating greater thyroid activity at the lower temperature.

232. EFFECT OF THE PHYSICAL FORM OF GRAIN ON THE RATE OF VOLATILE FATTY ACID PRODUCTION IN RUMINANTS. G. B. Garner, W. H. Pfander and M. E. Muhrer, *University of Missouri.*

The effect of changing the physical form of grain on the rate of digestion was studied. Artificial rumen and animal experiments were used. Whole, coarse, cracked, ground and flaked corn was obtained from the same lot. Whole, ground, crimped and pelleted oats were obtained from the same lot. The artificial rumen was charged with 50 gm. of test substance and 200 ml. of rumen fluid containing 0.5% $NaHCO_3$ equilibrated to pH 7.0 with CO_2. Volatile fatty acids (VFA) determinations and microscopic examinations were made. Microscopic examination revealed a marked increase in iodophilic protozoa on the flaked and ground corn substrate. Average VFA concentrations of six 4-hour *in vitro* trials with corn were found to be increased 2.20, 2.08, 1.76, 1.26 meq. VFA/100 ml. of rumen fluid above the basal for flaked, ground, cracked and whole corn, respectively. In similar trials with pelleted, crimped, ground and whole oats, the increased concentration of VFA over the basal was 4.84, 4.26, 1.79 and 1.31 meq. VFA/100 ml. of rumen fluid, respectively. VFA were produced more rapidly from flaked corn when compared to other forms of corn in fistulated sheep. In a similar *in vivo* comparison, pelleted and crimped oats were superior to ground or whole oats. It can be concluded that flaked corn and pelleted oats are superior to other physical forms of these grains investigated. Contribution from the Missouri Agricultural Experiment Station, Journal Series No. 1789. Approved by Director.

233. FACTORS ASSOCIATED WITH LAMB MORTALITY IN RANGE PRODUCTION. A. S. Hoversland, J. Safford, J. L. Van Horn and O. O. Thomas, *Montana Agricultural Experiment Station, Montana State College, Bozeman, Montana.*

Of 6,745 lambs born to range white-face ewes, 1,469 (21.8%) either were born dead or died prior to weaning. Of the total 1,469 dead lambs, 239 (16.3%) were born dead and the remaining 1,230 or 83.7% lambs were born alive and died prior to weaning. The percent of lambs born dead and dying at ages of 1, 2, 3, 4, and 5 days was 16.3, 14.9, 11.1, 5.9, 5.0 and 1.9, respectively. The accumulative mortality for dead at birth and dying on days 1, 2, 3, 4, and 5 was 16.3, 31.2, 42.3, 48.2, 53.2 and

55.1%, respectively. A strength score, based on birth weight and vigor of lamb, was given all lambs at birth. Strength scores ranged from 1 (big, active lamb) through 5 (small, inactive lamb). Lamb mortality according to strength scores 1, 2, 3, 4, and 5 was 8.1, 9.3, 19.4, 40.9, and 66.9%, respectively. The average birth weight of females was 9.2 and males 9.9 lb. The average birth weight of female lambs that lived and died was 9.6 and 7.6 lb., respectively. The average birth weight of male lambs that lived and died was 10.3 and 8.6 lb., respectively. Lamb mortality rapidly reduced as the birth weights increased up to 8 lb., reached a minimum at 12 lb. and increased in the case of male lambs as birth weights were greater than 12 lb. At all birth weights, female lambs had a lower mortality than male lambs. Lamb mortality for males and females was 23.5 and 19.9%, respectively. All ewes were grouped according to weight gain during pregnancy by 5-lb. intervals. Ewes gaining from 20 to 24 lb. had the lowest mortality and it increased in the groups of ewes that gained more and also in groups gaining less than this amount. Mortality of single birth lambs from ewes loosing weight or gaining weight during pregnancy was 25.4 and 16.1%, respectively. Mortality of twin births from ewes loosing and gaining weight during pregnancy was 42.2 and 22.7%, respectively. Mortality in the lowest level of supplementation was 33.9% compared to 18.9% among ewes on the highest feed level.

234. THE RELATIONSHIP OF CERTAIN BLOOD CONSTITUENTS TO RATE AND ECONOMY OF GAIN IN BEEF CATTLE. R. L. Arthaud, A. B. Schultz, R. M. Koch and V. H. Arthaud, *USDA and University of Nebraska.*

Blood levels of glucose, hemoglobin and sulfhydryl erythrocyte counts, total eosinophil counts, and hematocrit values were determined in 1953 for each of 43 bulls (3 Angus, 31 Herefords and 9 Shorthorns). The first determinations were made when the bulls averaged 221 days of age and from 8 to 14 days after they were started on a 168-day performance test on a ration containing 64% TDN. Analysis of a second blood sample from each bull was made about 56 days later. In both samples blood glucose was most closely associated with 168 day total gain ($r=.44$ and .17, respectively) and with economy of gain expressed as pounds of TDN required for 100 lb. of gain ($r=-.41$ for both samples). Small, but significant, correlations were found between economy and total eosinophil count in both samples ($r=.31$ and .34, respectively) and between economy and hematocrit reading in the first sample ($r=-.33$). The correlations of the other blood constituents with both rate and economy of gain were low and were not significant. The six blood constituents plus age and initial weight jointly accounted for only 26% of the variance in total gain ($R=.51$). The standard partial regressions of gain on blood glucose, hematocrit value, erythrocyte count, and initial weight were .45, .41, —.40, and .38, respectively. These four factors made the greatest individual independent contributions to total gain. All analyses were on the within breed portion of the variances and covariances.

235. THE RELATIONSHIP OF MILK PRODUCTION IN DAIRY COWS TO ITS COMPONENTS, MAXIMUM INITIAL MILK YIELD AND PERSISTENCY OF LACTATION. H. D. Lennon, Jr. and J. P. Mixner, *New Jersey Agricultural Experiment Station.*

A correlation study was performed on a "total", "among lactations", and "among cows in lactation" basis with 81 Holstein lactation records to determine the effects of maximum initial milk yield and persistency of lactation on milk production. Lactation milk production was the 240-day 4% FCM production, maximum initial milk yield was the highest test-day 4% FCM production, and the persistency index (P) was according to Brody *et al.* and Gaines in which decline of milk is represented exponentially and $P=100-(k \times 100)$ in which k equals the rate of decline in milk yield per month on an instantaneous basis. Maximum initial milk yield and persistency were highly

correlated with lactation milk production (0.78 and 0.36, respectively) on an "among cows in lactation" basis, while they had no correlation with each other (0.01). This indicates that maximum initial milk yield and persistency are independent factors which collectively influence lactation milk production (R=0.85). On an "among lactation" basis, lactation milk production and persistency were negatively correlated (−0.76) which expresses the observed effects of age or maturity on persistency of lactation. In an analysis of variation associated with lactation milk production, the effects associated with the correlation of maximum initial milk yield with lactation milk production accounted for 60.4% of the total variation. The additional effect due to persistency contributed 12.6% to the total variation. Body weight, as an additional factor to lactation number, had very little effect on lactation milk production.

236. AN EMULSION SUITABLE FOR THE QUANTITATIVE INTRAVENOUS INTRODUCTION INTO ANIMALS OF FAT-SOLUBLE SUBSTANCES, ESPECIALLY DYES. D. J. Horvath, D. L. Black and G. H. Wellington, *Cornell University*.

Dilution of known amounts of appropriate indicators in the body fat of animals might permit estimation of total fat by calculation from biopsy sample analyses. It was found that such materials can be dissolved in corn oil which can then be emulsified. The sequence of operations described by Geyer *et al.*, (J. Am. Oil. Chem. Soc., 32:365, 1955) was followed except that a nitrogen atmosphere was not employed. The following constituents were emulsified at 3000 psi. Corn oil (35%) containing the dye or other substance, Pluronic F-68 (Courtesy Wyandotte Chemicals Corp.) (4%), glycerol (5%), ethanol (5%) and a 5.5% dextrose solution (51%). For standardization analysis, the dye (anthraquinone violet was used in our studies) can be extracted from the emulsion with 50:50 ethanol-toluene, evaporated, redissolved in a suitable solvent and the concentration determined spectrophotometrically.

237. SEMEN PRODUCTION IN YOUNG BOARS COLLECTED ONCE A DAY VERSUS EVERY THREE DAYS. A. R. Turkheimer, D. C. Young and R. H. Foote, *Cornell University*.

Semen production in young boars was studied by means of frequent collections with the artificial vagina, using a gilt in a breeding crate for a mount. In preliminary trials semen was first collected from one of six boars tested at 130 days of age. Subsequently, 6 Yorkshire boars from two litters were selected from a group of 16 boars. The selection was based on their interest and willingness to serve the artificial vagina at an early age. At 10 months of age three boars were placed on a once-every-three-day, and three on a once-every-day collection regimen for three weeks. Both groups then were rested for five days and reversed for three additional weeks. Average weights for the six boars at the beginning of the experiment were 296 lb. and at the end, 326 lb. Criteria studied and mean values obtained for the daily and once-every-three-day groups, on a per ejaculate basis, were respectively: total volume, 179 ml., 246 ml.; strained volume, 125 ml., 173 ml.; gel volume, 57 ml., 73 ml.; sperm per ml., 178×10^6, 269×10^6; initial motility, 53%, 58%; total sperm per ejaculate, 22.8×10^9, 45.1×10^9; total motile sperm per ejaculate, 13.2×10^9, 25.7×10^9; pH, 7.82, 7.79; teasing time, 2.8 min., 2.7 min.; and ejaculation time, 3.7 min., and 4.1 min. Livability of each ejaculate was tested in an egg yolk-citrate-glycine-glucose extender stored at 5° C. The mean percentages of motile sperm after 1, 2, 4, 6, and 8 days of storage for the daily group were, respectively, 43, 39, 25, 9, and 2%. For the group collected once every three days, the corresponding percentages were 47, 40, 28, 12, and 4%.

238. LIVABILITY OF BOAR SPERM STORED IN VARIOUS EXTENDERS AT 5, 15 and 25° CENTIGRADE. D. C. Young, A. R. Turkheimer and R. H. Foote, *Cornell University.*

Semen used in these studies was obtained from young Yorkshire and Chester White boars with an artificial vagina. Sodium citrate, phosphate, sodium bicarbonate, glucose, glycine, glycerol, inositol, and egg yolk were combined in more than 200 different extenders and storage procedures to store boar semen in sealed ampules and corked tubes at 5, 15, and 25° C. The semen to extender ratio was 1:4. Sperm in extenders containing more than 1.45% sodium citrate or phosphate died within 24 hours. Twenty percent egg yolk was significantly superior to 50% yolk. Adding 5 or 10% glycerol decreased motility during storage, but not significantly so during the first day when semen might be frozen. Sealed ampules preserved motility significantly better than corked tubes, the average percentage of motile sperm after four days of storage being 30 and 21%, respectively. The average percentages of motile sperm after four days storage at 5, 15, and 25° C. were 21, 34, and 23%, respectively. The results at 15° C. were significantly superior to those obtained at 5 and 25° C. Considering all treatments the best results were obtained with sealed ampules stored at 15° C. using a medium containing 20% yolk, .33% citrate, .33% glycine and 1% glucose. The average motility after 1, 2, and 4 days of storage was 62, 56, and 37%. Additions of .75% sodium bicarbonate and 1.25% inositol to this extender gave similar results.

239. RELATION OF LIFE SPAN OF RED BLOOD CELLS TAGGED WITH CHROMIUM-51 TO CORPUSCLE GLUCOSE IN YOUNG CALVES. J. H. Vandersall, H. R. Conrad and J. W. Hibbs, *Ohio Agricultural Experiment Station.*

Five calves, 3 Jerseys and 2 Holsteins, were used in a study relating red blood cell life span and corpuscle glucose (reducing sugar) during the first 10 weeks. A high roughage ration was fed with whole milk to 7 weeks of age. On the 3rd day, 25 ml. of blood was drawn and incubated with approximately 350 μc of Cr-51 (Rachromate) at 37° C. for 2 hours. The labeled cells were washed twice with cold saline, resuspended in saline and reinjected. Jugular blood samples were drawn daily for the first 3 days; semi-weekly to 4 weeks; and weekly thereafter. An aliquot of whole blood was acidified and counted in a discriminating well-type scintillation counter. For the first 3 days post-injection, a plasma sample was counted and the activity of the cells calculated. After this time no appreciable activity remained in the plasma. The samples were also analyzed for whole blood glucose, plasma glucose and red cell volume. Corpuscle glucose was calculated. As previously reported, much of the decline in whole blood glucose during the first few weeks was due to a decline in the glucose of corpuscle fraction. In this study the decline in corpuscle glucose was found to correspond closely to the rate of disappearance of Cr-51 tagged foetal red blood. This indicated that the decline was due to a dilution of the foetal cells which were high in glucose with new cells which were lower in glucose content.

240. RED AND WHITE CELL COUNTS IN GENETICALLY DIFFERENT GROUPS OF BEEF CATTLE. Donald A. Price, Ralph Bogart, Graham Alexander and Hugo Kruger, *Oregon State College.*

At 500 lb. body weight blood hemoglobin of beef cattle under uniform environmental conditions ranged from 9.7 to 14.0 gm. per 100 ml., with an average of 12.1 gm. per 100 ml. The hematocrit reading (corpuscle volume) ranged from 31.5 to 48.3 with an average of 39.6% of blood volume. Red cell counts ranged from 6.0 to 9.8 with an average of 7.73 million per cu. mm. Mean corpuscular volume was 51.8 cu. microns with a range of 43.9 to 59.5. Hemoglobin per cell ranged from 26.5 to 37.2 micro-micrograms with an average of 32.7. At 800 lb. body weight hemoglobin for

Angus males was 13.6 gm. while for Hereford males it was 12.9 gm. and the corresponding hematocrit values were 47.0 and 42.2% for males of the two breeds. Red cell counts were 8.5 million per cu. mm. for Angus males and 8.0 million for Hereford males. The average values for males of the three Hereford lines ranged from 12.8 to 13.0 gm. for hemoglobin, 41.9 to 43.7% for hematocrit and 7.8 to 8.1 million for red blood cells. The average values for heifers of the three Hereford lines ranged from 13.0 to 13.1 gm. for hemoglobin, 38.6 to 45.6% for hematocrits, and 8.0 to 8.8 million for red cell counts. There were no differences in any of these blood constituents associated with line of breeding within the Hereford breed. The leucocyte count for cattle averaged 9,630 per cu. mm. with a range of 6,600 to 14,000. Male calves had lower levels of hemoglobin and red cell counts than female calves at both 500 and 800 lb. weights. Hereford male calves exhibited a lower average of hemoglobin, hematocrit, red cell count and neutrophil percentage and a higher lymphocyte percentage in the cellular constituents of the blood than the Angus male calves at both weights. Hereford females at 500 lb. exhibited higher average lymphocyte and lower average neutrophil percentages than Angus females. Among the three lines of Herefords, the only differences between lines was that at 500 lb., Prince females showed higher suckling gains and higher average eosinophil and neutrophil percentages than David females. Although blood hemoglobin, red cell count, and hematocrit values were highly interrelated, only hemoglobin values were correlated with rates of gain and feed efficiencies.

241. A COMPARISON OF THE IMPLANTATION OF DIETHYLSTILBESTROL AND HEXESTROL AND THE FEEDING OF DIETHYLSTILBESTROL. F. N. Andrews, W. H. Smith, T. W. Perry, Martin Stob and W. M. Beeson, *Purdue University.*

Six lots of 12 heifers each were used. The animals weighed approximately 460 lb. at the start of the experiment on November 5, 1956 and were marketed 195 days later at a weight of approximately 900 lb. The heifers consumed about 40 lb. of corn silage and 3.5 lb. of Purdue Supplement A daily. Lot I was the control; Lot II was fed 10 mg. of diethylstilbestrol (DES) daily; Lot III was implanted with 24 mg. of DES; Lot IV 36 mg. DES implants; Lot V 24 mg. hexestrol implants and Lot VI 36 mg. of hexestrol implants. The average daily gains by lots were: Lot I, 2.11 lb.; Lot II, 2.28 lb.; Lot III, 2.17 lb.; Lot IV, 2.33 lb.; Lot V, 2.31 lb.; and Lot VI, 2.21 lb. The improvement in rate of gain was highly significant in Lots IV and V ($P<0.01$). The improvement in feed efficiency by estrogen treatment was very small in comparison to that usually observed in steers. Carcass grades were closely similar in all lots. A serious problem, vaginal prolapse, was encountered in nine of 24 heifers implanted with DES and in two of 12 heifers implanted with 36 mg. of hexestrol.

242. STUDIES ON THE BREEDING SEASON OF NEW ZEALAND ROMNEY EWE LAMBS. T. S. Ch'ang and J. I. Raeside, *Massey Agricultural College, Palmerston North, New Zealand.*

In 1956 and 1957, 95 and 72 ewe lambs respectively, were depastured continuously during the Autumn and Winter with three ochred vasectomized rams. In 1956, 48 lambs showed one or more estrus (cycling class), 19 lambs exhibited no estrus (non-cycling class) and the remainder were used in an attempt to induce estrus by hormone injections. The breeding season extended from mid-March to the end of July and was not spread evenly about the shortest day. The extent of the onset of first estrus was approximately three months with the highest incidence (56%) in May. In 1957, the cycling class consisted of 64 and non-cycling class 8 lambs. While the duration of breeding season was slightly longer, the extent of the onset of first estrus was similar to the previous year. For 1956 and 1957, the length of estrous cycle was

17.24±1.33 and 17.44±1.57 days and the number of estrous cycles per lamb in the cycling class was 2.71±1.39 and 4.28±1.70. Estimates of age and body weight at first estrus were obtained after allowing for effects due to sire, age of dam and type of rearing of the lamb. These were 273 and 260 days and 75 and 83 lb. for the first and second year. In 1956, cycling lambs were characterized by significantly earlier date of birth (14 days) and heavier body weight (5 lb.) at a constant age (273 days) than non-cycling lambs. Difference in yearling fleece weight was not significant after allowing for differences in body weight between cycling and non-cycling lambs. Two-year-old reproductive performance of lambs studied in 1956 will be reported.

243. CONCENTRATION OF FLUORINE IN URINE OF CATTLE AND SHEEP. G. M. Merriman and C S.. Hobbs, *University of Tennessee.*

Urinary fluorine concentrations in single viodation, and 1, 3, and 7-day composite samples were studied for 123 cattle and 72 sheep. The animals were fed different levels of fluorine from sodium fluoride, raw rock phosphate, or fluorine contaminated pastures. Effects of two "alleviators" (aluminum sulfate and aluminum chloride) were studied. Less variability was found in observed urinary fluorine values than those corrected to a standard specific gravity. Reliability of fluorine values for single voidation samples was greatest when samples were collected eight to sixteen hours after ingestion of fluorine. Cattle consuming 8 ppm of fluorine in the control rations had urinary fluorine concentrations of 1 to 7 ppm. Urinary fluorine concentrations did not correlate with high concentrations in the ribs of cattle 250 days after cessation of high fluorine intake. Feeding aluminum sulfate or aluminum chloride caused reductions in urinary fluorine concentration. Study of urinary fluorine values cannot stand alone as a diagnostic aid in bovine fluorosis.

244. THE INFLUENCE OF SHADING ON THE RESPONSE OF CATTLE TO VARIOUS ENVIRONMENTAL VARIABLES. Robert R. Shrode and James S. Williams, *Texas A. and M. College.*

Two series of tests were conducted during the summers of 1955 and 1956. Eighteen heifers used in the 1955 series consisted of six Jerseys, six ½ Jersey-½ Brahmans and six ¾ Jersey-¼ Brahmans, while those used in the 1956 series were six Jerseys, six ¾ Jersey-¼ Brahmans and six Holsteins. Solar radiation, air temperature, vapor pressure and wind velocity were continuously recorded, and physiological measurements (rectal temperature, respiration rate and pulse rate) on the animals were taken initially and at hourly intervals beginning at 6 a.m. and ending at 5 p.m. on each test day. During each test day, two animals of each group were kept in shades so constructed that air temperature, vapor pressure and wind velocity in the shade thus provided were the same as in open shade. Each series consisted of nine test days, giving each animal three days of data collection under shade and six days in direct solar radiation. The data were subjected to multiple regression analysis, using the environmental variables as independent variables and the physiological measurements from the animals as dependent variables. "Shade" data, with three independent variables, were analyzed separately from "sun" data, with four independent variables. Both "shade" and "sun" data confirm the conclusion, drawn from similar studies previously conducted without shades, that at high air temperatures (above 90° F.) variation in solar radiation loses most of its effectiveness in producing animal responses.

245. NUMBER, WEIGHT, AND PROGESTERONE CONTENT OF CORPORA LUTEA IN PREGNANT GILTS. Robert G. Loy, W. H. McShan, H. L. Self and L. E. Casida, *University of Wisconsin.*

Gilts were slaughtered at 25, 70 and 105 days of gestation and numbers and weights of corpora lutea determined. Chemical analyses of progesterone were made on

the corpora lutea from the 70-day stage. The correlation of number and average weight of corpora lutea was —0.34, $P<0.05$ as calculated between gilts and —0.04 between ovaries within gilts. The correlation of average weight in the right ovary and in the left ovary was 0.79, $P<0.01$, and of number of corpora lutea in the right ovary and in the left ovary was —0.44, $P<0.01$. The standard partial regression of total luteal tissue on average weight of corpora lutea was 0.80, and on number was 0.95. Correlations of 0.44, $P=0.09$ were calculated between gilts for average weight of corpora lutea and progesterone concentration, and of —0.46, $P=0.08$ between number and concentration. Between ovaries within gilts these correlations were 0.01 and —0.03 respectively. The correlation of progesterone concentration in the right ovary and in the left ovary was 0.78, $P<0.01$. Standard partial regressions of total amount of progesterone on total luteal tissue was 0.43 and on progesterone concentration 0.90. A correlation of 0.00 was found between amount of luteal tissue and progesterone concentration.

246. PRELIMINARY STUDIES ON THE ACCEPTANCE, TOLERANCE AND EFFECTS OF NEOMYCIN SULFATE ADMINISTERED TO LIVESTOCK FOR ENTERIC THERAPY. J. Lavere Davidson, and Nolen D. Connor, *The Upjohn Company*.

Biosol, a new preparation containing soluble neomycin sulfate for addition to the drinking water of animals, is in the initial stages of clinical testing and has been administered to dairy cattle, calves, swine, sheep, horses, and chickens. In addition to its therapeutic effects in treating various types of diarrhea in livestock (as well as in pets) it has shown promise as a prophylactic in reducing the spread of diarrhea in groups of animals in which the condition has started. An important facet to the administration of Biosol to mature dairy cattle is its apparent lack of producing untoward effects on rumen function. Preliminary studies show a possible increase in rate of gain in young animals administered the preparation in the drinking water. Administration to various forms of livestock has not resulted in toxic manifestations.

SUBJECT INDEX FOR ABSTRACTS

(Numbers refer to Abstract number, not page number)

A

Age, weight and milk yield of Holstein-Friesian cows, 129
Alfalfa—
  Chopped vs. pelleted for lambs, 50
  Effect of irrigation and time of day on composition, 98
  Levels in swine rations, 62
  Leaf meal for swine, 165
Androgenic chromogens in ruminant urine, 73
Animal fat and proteins for cattle, 171
Animal grease for lactating cows, 109
Antibiotics—
  Palatability by swine, 162
  And bacterial agents for swine, 153
Antibody—
  Absorption by baby pigs, 76
  Formation in chicks, 133
  Production by baby pigs, 57
Apple pomace as roughage, 198
Arsanalic acid for swine, 152

B

Bactericidal activity of rabbit uterine exudate, 69
Beef Calves—
  Influence of factors on preweaning growth, 3
Beef carcass—
  Body measurements, and, 27
Beef heifer weights—
  Nutritional levels on, 24
Birth weight and growth of cattle, 4
Bloat—
  Blood changes in, 78
  Various agents for control of, 79
Blood—
  Calcium of cattle, 18
  Constituents and rate of gain, 234
  Effect of temperature and fasting on fat, 77
  Fat and swine carcasses, 231
  Group systems in sheep, 215
  Serum proteins, 223
  Studies of pure and crossbred cattle, 181
Boars—
  Buyer preference for known merit, 81
Boar sperm storage, 238
Breeding season for New Zealand Romney ewe lambs, 242
Butylated hydroxy anisole and meta bisulfite in rations, 193

C

Caecum—
  Role of in pigs, 58
Calcium—
  And fat in ruminant digestion, 176
  And phosphorus metabolism affected by zinc and aluminum, 196
Calf starters—
  Effect of anise oil on palatability of, 96
Calorie value of TDN, 97
Carcass characteristics of steers, 146
Carcass merit of swine, 123
Carotene value for bovine, 14
Cattle—
  Blood comparisons of Brahman and British, 33
Cellulolytic factors—
  In distillers dried solubles, 94
Chlortetracycline—
  And stilbestrol for steers, 47
  In various feeds for lambs, 49
  On calcium metabolism of calves, 189
Choice cattle for profit, 36
Confirmation and production of steers, 2
Consumer preference of beef, 145
Copper low natural ration, 199
Corn—
  High oil and protein for lambs, 184
Corpora lutea of gilts, 245
Creatinine—
  An index of ruminant nutrition, 9
Crossbred beef cattle in Gulf Coast, 28
Cytology of spermatogenesis in bulls, 132

D

Dairy calves—
  Dry feeds for, 156
Digestibility of rations by lambs, 159
Dry matter in fresh forages and silages, 182
Duodenal fistula studies, 230
Dwarf carrier cows for gene testing, 29
Dwarf cattle—
  Changes in insulin stress, 32
  Measurements of snorter, 30
Dwarfism in beef cattle, 31

E

Enzymes for baby pigs, 60
Estimating clean fleece weight, 126
Estradiol—
  And FSH on estrus in gilts, 222
  Progesterone implants for lambs, 42
  Progesterone implants on steers, 183
  Effect on estrous behavior in cows, 202
Estrogen—
  Anabolic response, 214
  Excretion by cows, 225
Estrus and ovulation—
  effect of energy and protein on, 212
Exercise on ham muscles, 141

F

Factors influencing sheep response to corn oil, 178
Fat emulsions for intravenous use, 236
Fatness on palatability of pork, 136
Fatty acids in sheep rumen contents, 110
Feather meal for swine, 149, 150
Feed utilization of bulls, 26
Fescue forage and seed for small animals, 166
Fluorine—
  In cattle urine, 243
  Radioactive in cattle tissues, 19
Flushing, effect on ovulation, 210
Full vs. limited feeding of breeding pigs, 82
Furazolidone and fat for pigs, 154, 155

G

Genetic and phenotypic traits of cattle, 1
Genetic components and performance of steers, 5
Goitrogens in tissue following thiouracil feeding, 119
Gonadotropic hormone—
  Induction of estrus, 205
Gossypol poisoning—
  Histopathology of, 161
Grades of hams, 135
Grass silage and different grain levels for milk production, 101
Growth stimulants for swine, 163

H

Ham as indicator of carcass value, 140
Hay, silage or pasture for heifers, 104
Heat tolerance in cattle, 226
Hemoglobin in fetal calves, 228
Heritability—
  Of carcass characters in swine, 124
  Of economic traits in bulls, 6
  Of growth rate, 7
  Of weaning weight of lambs, 22
Hormones—
  Influence on estrus, ovulation and fertility, 204
Hygromycin A—
  For lambs, 48
Hypothalamic lesions on mating behavior, 201

I

Iodine compounds on protein-bound iodine, 112
Iodine, serum protein bound—
  And rates of gain, 34
Inheritance and tenderness of beef, 25
Intake as a measure of forage value, 99
In vitro studies—
  Activities of rumen microorganisms, 177
  Digestibility of purified cellulose, 174
  Effect of amino acids on cellulose digestion, 175
  Higher fatty acids formed, 224
  Techniques for rumen procedure, 179
Iron for baby pigs, 54
Irradition of beef, 144
Irradiation effects on female rats, 67
Isoimmune antibodies in cattle and sheep, 216

L

Lamb rations—
  Effect of potassium orotate and methionine, 191
Leanness of swine—
  Urinary and blood creatinine as measure of, 75
Level of feeding—
  On ovulation rate, 211
  On efficiency of ration utilization, 185
Litter size and growth rate of swine, 125
Livestock and meat grades—
  Graphic presentation of, 86

M

Magnesium—
  Requirement of pigs, 56
  Utilization by calves, 90
Maintenance of aged bulls, 158

Marketing hogs by grade, 37
Meadow crops for beef production, 100
Melanin content of cattle hair, 35
Methyl testosterone orally for swine, 20
Milk meters—
  Milk production relationships, 235
  Problems of, 85
Molybdenum, copper and cobalt for heifers, 13
Mucin in bloat prevention, 168
Muscular dystrophy in lambs, 88
Mycostatin for swine, 163

N

Neomycin for livestock, 246
Nitrogen fertilization—
  On digestibility of bromegrass hay, 93
Nutritional stress on sheep, 8

O

Oats for swine, 148
Orchardgrass, N fertilized vs. alfalfa for milk production, 102

P

Pasture—
  Gains of cattle, 107
  Everglades pastures for cattle, 105
Performance testing—
  Of beef cows, 23
  Of sheep, 87
Pelleted roughage in fattening rations, 173
Phosphorus and protein for swine, 151
Photographs of beef marbling, 142
Physical form of rations for lambs, 160
Pituitary gonadotrophin—
  Effect of factors on, 203
Pituitary release of lactogenic hormone, 71
Placental attachment in bovine, 68
Potato pulp in steer rations, 190
Probing technique in selecting breeding swine, 84
Production of artificially and naturally sired cows in Georgia, 130
Progesterone—
  Content of swine corpora lutea, 207
  Injections on reproductive performance in gilts, 209
  In mineral and nitrogen metabolism, 213
  On corpus luteum of ewes, 208
Prolactin release in rats, 72
Prolificacy in farm sheep, 120
Protein—
  And calorie intake of calves, 11
  And phosphorus for range cattle, 106
  Energy ratios for fattening cattle, 91
  Intake on blood composition, reproduction and gains, 218
  Levels and B vitamins for swine, 164
  Supplements for beef cattle, 172
Protein-bound iodine—
  Variations in serum, 134
Purified rations—
  For lambs, 89
  Nitrogen and cellulose on digestion of, 92

R

Red blood cells—
  And white cells of cattle, 240
  Life of in cattle, 239
Renal function in cattle, 17
Reproduction in a Hereford Herd, 121
Reserptine effects on lactation, 70
Retrogression of the rumen, 180
Rice for lambs, 169
Roughage—
  Intake and size of heifers, 131
  High and low quality for steers, 192
Rumen—
  Bacteria, effect of ration on, 51
  Blood flow, 16
  Development, 12
  Grain form and fatty acids, 232
Rumen products—
  Feeding value of dried, 95
Rump inclination and age of dairy cattle, 128

S

Saccharin—
  And sugar in pig starters, 61
Saliva from bovine, 15
Sarcosine and creatine as N for ruminants, 74
Section index in sheep, 80
Selenium—
  And arsanilic acid for swine, 65
Semen—
  Production of boars, 237
  Storage, 221, 227
Serum mineral levels in cows with milk fever, 188

Sewage sludge as nitrogen source, 187
Sexual odor in boars, 21
Shade and temperature of cattle, 244
Shearing—
  Date effect on ewe performance, 219
  Vs. tagging of ewes at breeding, 229
Smoking of hams, 139
Specific gravity and marbling, 143
Spermatogenic capacity of bulls—
  Effect of energy intake and growth on, 66
Spermatozoan metabolism inhibition by CO_2, 220
Staple length of Targhee sheep, 127
Stilbestrol—
  And B_{12} on NPN use, 44
  And chlortetracycline for steers, 47
  And growth hormone on nitrogen retention, 206
  And progesterone-estradiol implants on steers, 183
  And tetra alkylammonium stearate for fattening steers, 46
  For suckling calves, 157
  Implants vs. feeding, 241
  On bone, Ca, P, and N utilization of lambs, 43
Stilbestrol implants—
  Absorption in steers, 38
  And chloreteracycline for beef calves and heifers, 40
  And Synovex for beef calves, 41
  For grazing yearling cattle, 39
  For steers on pasture and dry lot, 108
Swine—
  Development of Minnesota No. 3, 83
Swine Carcass—
  Improving firmness, 137
  Stabilization by antioxidants, 138

T

Tallow, corn and oats for swine, 147
TDN of corn rations, 194
Temperature—
  On thyroid I^{131} activity, 115
  Variations during estrus and pregnancy, 200
Thiouracil feeding on I^{131} release, 114
Thyro-active compounds for lactating sows, 64
Thyroid activity and embryonic mortality of gilts, 122
Thyroid function, relation of temperature and vitamin A requirement, 116
Thyroid secretion rate—
  By dairy goats, 113
  Estimated by extrapolation, 117
  In cattle, 118
Thyroprotein for lactating sows, 63
Thyroxine for identical twin cows, 111
Tranquilizers in cattle and lamb rations, 10
Triiodothyronine for swine, 163

U

Urinary calculi—
  Relationships of concentrate feeding and, 217
Use of N sources by lambs, 159

V

Value of baled, chopped and pelleted hay, 103
Vitamin A and phosphorus for calves, 195
Vitamin and trace mineral supplementation, 197
Vitamin E—
  And selenium for pigs, 53
  Deficiency in baby pigs, 52

W

Whey in swine diets, 59

Z

Zinc deficiency in pigs, 55

AUTHOR INDEX FOR ABSTRACTS

(Numbers refer to Abstract, not page number)

A

Adams, C. H., 91
Adams, H. P., 165
Acker, D. C., 157
Akers, W. T., 53
Albert, W. W., 41
Aldinger, S. M., 61
Alexander, Graham, 240
Allen, A. D., 205
Allen, R. J., 105
Allen, R. S., 98, 167, 223
Alsmeyer, R. H., 137, 146
Alsmeyer, W. L., 60, 150
Anderson, G. C., 44, 74, 89, 138
Anderson, L. L., 222
Anderson, R. R., 17
Andrews, F. N., 241
Andrews, G. P., 197
Arthaud, R. L., 30, 234
Arthaud, V. H., 30, 234

B

Baird, D. M., 107
Baker, F. H., 48, 94, 176
Baker, T. I., 174
Banks, W. C., 32
Bartley, E. E., 168
Bartlett, J. W., 131
Baumgardt, B. R., 93
Beardsley, D. W., 55, 105
Becker, D. E., 59, 64, 148
Bedrak, E., 218
Beeson, W. M., 56, 151, 153, 241
Bell, M. C., 166, 196
Bell, D. S., 42
Bentley, O. G., 42, 174, 179
Birmingham, E., 135
Bitman, Joel, 200
Black, D. L., 236
Blackwell, R. L., 5
Bogart, Ralph, 240
Bohman, V. R., 171
Bonnington, G. H., 101
Botkin, M. P., 87
Bradley, N. W., 41
Brady, D. E., 135
Bratzler, L. J., 136, 143
Brannan, D. D., 145
Branton, Cecil, 129
Bray, R. W., 141
Brehour, J. R., 43
Breidenstein, C. P., 101
Briggs, J. E., 155
Briskey, E. J., 141
Brooks, J., 74
Brown, C. J., 26, 169
Brown, H., 76
Brown, L. R., 79, 167
Brugman, H. H., 190
Brunstad, G. E., 122
Burris, M. J., 198
Burroughs, Wise, 19, 45, 114, 175, 206, 224
Bush, L. J., 189
Butcher, J. E., 9, 106
Butler, J. K., 37
Butler, O. D., 25
Byers, J. H., 185

C

Cahill, V. R., 27
Campbell, C. D., 44, 74, 89
Carmon, J. L., 96, 130, 147, 219
Carpenter, J. W., 146, 181
Carter, R. C., 1, 7, 23
Cartwright, T. C., 22, 25
Casida, L. E., 207, 208, 210, 211, 245
Cason, J. L., 93
Cate, H. A., 103, 173, 183
Catron, D. V., 61, 63, 76, 116
Chamberlain, C. C., 19
Chambers, Doyle, 121
Ch'ang, T. S., 242
Chapman, A. B., 80, 123, 211
Chapman, H. L., 13, 47, 105, 146
Chappell, V. E., 184
Cheng, C. S., 115
Cheng, Edmund, 115, 175
Christian, R. E., 21
Clark, R. T., 2, 6
Clark, R. L., 127
Clegg, M. T., 201, 214
Clum, H. V., 4
Cmarik, G. F., 103, 173, 183
Cole, J. W., 145
Combs, G. E., 60, 150, 163
Conner, H. G., 15
Connor, N. D., 246
Conrad, H. R., 16, 239
Conrad, J. H., 151, 153
Cook, A. C., 212
Cook, C. W., 106
Cook, R. H., 135
Cooksey, J. H., 123
Cotton, T. E., 147
Cover, Sylvia, 25
Cox, R. F., 108
Crampton, E. W., 58, 99
Crown, R. M., 28
Cunha, T. J., 33, 40, 218

D

Dale, D. G., 58
Dalton, H. L., 96
Damon, R. A., 28
Danion, J. R., 219
Davidson, J. L., 246
Davis, G. K., 181
Davis, H. P., 128
Davis, R. E., 11, 212
Davis, W. F., 163
Day, B. N., 222
Dayton, E. W., 184
Deans, R. J., 231
Dehority, B. A., 179
Deyoe, C. W., 32
Dickey, H. C., 190
Dietrich, J. P., 85
Diggs, B. G., 161
Dollahon, J. C., 31
Donker, J. D., 158
Dowe, T. W., 91
Draper, H. H., 52
Dudley, W. A., 64
Duncan, C. W., 15, 228, 230
Durham, R. M., 81, 140
Dyer, I. A., 46, 192

E

Easley, G. T., 121
Eby, Claude, 102

Edwards, G. M., 209
Eggert, R. G., 53
Ellis, W. C., 92
Embry, L. B., 95, 159
Emerson, John, 47
Endfield, F. D., 124
Ensminger, M. E., 82, 192
Erwin, E. S., 14

F

Faulkner, E. K., 87
Fechheimer, N. S., 35, 132
Felts, V. L., 80
First, N. L., 227
Fisher, R., 194
Flamboe, E. E., 113
Flatt, W. P., 12
Fletcher, M. D., 40
Flower, A. E., 62
Flynn, L. M., 193
Foote, R. H., 237, 238
Foote, W. C., 211
Forbes, R. M., 52, 55, 110
Formica, S. D., 197
Fowler, S. H., 82, 122
Frape, D. L., 116
Frost, D. V., 152

G

Gaines, J. A., 3, 23, 125
Ganong, W. F., 201
Garner, G. B., 51, 193, 232
Garrigus, U. S., 184
Gaskell, R. L., 214
Gasler, F. G., 159
Gawienowski, A. M., 73
Gehrke, C. W., 194
Gier, H. T., 68
Gifford, Warren, 26
Gilmore, L. O., 35, 132
Goetsch, G. D., 18
Gould, N. R., 98
Graf, G. C., 199
Grainger, R. B., 48, 94, 176
Greeley, M. G., 172
Green, G. G., 34, 134
Gregory, P. W., 29
Grimes, R. M., 228
Grosvenor, C. E., 71
Grummer, R. H., 141
Gurland, J. W., 225
Guthrie, J. E., 155

H

Hackler, L. R., 187
Hahn, E. W., 130
Haines, C. E., 163, 209
Haldiman, J. T., 68
Hale, W. H., 10, 38
Hall, O. G., 149
Hamblin, F. B., 226
Hanka, L. J., 202
Hansard, S. L., 19, 196
Hanson, L. J., 59
Hardison, W. A., 199
Hare, J. H., 162
Harris, L. E., 9, 106
Harrison, H. N., 180
Harshbarger, K. E., 188
Hartman, Roberta, 217
Harvey, W. R., 84
Hatcher, B. W., 78
Hatfield, E. E., 184, 187
Hathaway, I. L., 128
Hawk, H. W., 69
Hawkins, G. E., 90
Hays, R. L., 213
Hays, V. W., 61, 63, 116
Hazel, L. N., 81, 125, 222
Henderson, H. E., 229
Hendrickson, R. F., 157
Henneman, H. A., 204, 227, 229
Hentges, J. F., 31, 33, 40, 218
Hetzer, H. O., 84
Hibbs, J. W., 16, 239
Hill, F. D., 223
Hiner, R. L., 20
Hobbs, C. S., 19, 145, 243
Hoefer, J. A., 54, 57, 77, 177
Hogue, D. E., 88
Homeyer, P. G., 61, 79, 98, 167
Hoekstra, W. G., 141
Hourihan, M. E., 127
Horvath, D. J., 236
Hoversland, A. S., 233
Howes, J. R., 33
Huffman, C. F., 15, 230
Hughes, J. S., 73
Hunter, J. E., 2
Hupp, E. W., 85

I

Ittner, N. R., 50

J

Jaap, R. G., 133
Jackson, H. D., 18, 78
Jacobson, N. L., 79, 98, 167, 189, 223
James, L. F., 106
Jensen, A. H., 59, 64, 148
Jessup, G. L., 126
Johnson, B. C., 110, 187
Johnson, C. W., 63
Johnson, H. D., 115
Johnson, J. E., 226
Johnson, R. H., 79, 98, 167
Johnson, R. M., 72
Johnson, R. R., 42, 179
Johnston, E. F., 20
Jordan, C. E., 151
Jordan, R. M., 191
Julian, L. M., 29

K

Kamstra, L. D., 95
Kelly, Jack, 37
Kemp, J. D., 139
Kendall, K. A., 188, 213
Ketchum, J. L., 193
Kidder, R. W., 4, 47, 105
Kidwell, J. F., 2
Kiehl, E. R., 135
Kincaid, C. M., 1, 7, 23
King, J. X., 84
King, R. P., 224
Kirk, W. G., 181
Kline, E. A., 140
Klosterman, E. W., 27, 100
Knox, J. H., 5
Koch, B. A., 108
Koch, R. M., 30, 234
Koger, M., 4, 31, 203
Krueger, Hugo, 240
Kuhn, G., 38
Kunkel, H. O., 32, 34, 49, 134
Kunkle, L. E., 100

L

Lasley, E. L., 140
Lasley, J. F., 205
Lassiter, C. A., 228
Lennon, H. D., 112, 235
Lewis, R. C., 85, 117
Lewis, W. R., 138

Lidden, J. M., 4
Lindley, C. E., 121
Lister, E. E., 99
Lloyd, L. E., 58, 99
Lodge, J. R., 117
Loosli, J. K., 12, 88, 180
Lowrey, R. S., 219
Loy, R. G., 245
Luecke, R. W., 54, 57, 177
Luther, H. G., 10, 38
Lyman, C. M., 134
Lynch, G. P., 138
Lyons, D. T., 160
Ma, C. S., 166
Magee, W. T., 143
Maner, J. H., 147, 219
Manger, R. E., 66
Marion, G. B., 68
Markley, R. A., 93
Marlowe, T. J., 3
Mather, R. E., 101, 102, 131
Matsushima, J., 91
Mayo, R. H., 56
McArdle, F. J., 144
McCraine, S. E., 28
McCullough, M. E., 104
McGregor, John, 46
McGilliard, A. D., 15, 230
McLaren, G. A., 44, 74, 89
McShan, W. H., 245
Meites, Joseph, 70, 72
Meiske, J. C., 177
Melampy, R. M., 202, 222, 225
Merriman, G. M., 166, 243
Meyer, J. H., 50
Miller, E. R., 54, 57
Miller, J. A., 172
Miller, R. F., 199
Miller, W. J., 96, 130
Miller, W. M., 111
Mitchell, G. E., 41, 182
Mixner, J. P., 17, 112
Mochrie, R. D., 109, 156
Moody, W. G., 139
Morris, Meredith, 11
Morrow, R. E., 77, 231
Moxon, A. L., 174
Muhrer, M. E., 51, 194, 232
Munson, A. W., 140
Murley, W. R., 156
Murphree, R. L., 67

N

Naumann, H. D., 135
Neale, P. E., 126
Nellor, J. E., 204
Nelson, A. B., 157, 172
Neumann, A. L., 182, 187
Neville, W. E., 104, 107
Norton, H. W., 182

O

Ogrinz, E. F., 102
Olson, O. E., 65
Orme, L. E., 75, 143
Overby, L. R., 152
Oxley, J. W., 8, 120

P

Pace, H. B., 67
Packett, L. V., 49
Palmer, A. Z., 47, 137, 146, 181
Patterson, E., 53
Payne, G. F., 195
Pearson, A. M., 75, 77, 143, 144, 231
Peacock, F. M., 181
Perdue, H. S., 152
Perry, T. W., 241
Pfander, W. H., 51, 92, 160, 178, 193, 194, 232
Phillips, P. H., 141
Pipes, G. W., 118
Plumlee, M. P., 56, 151
Pope, A. L., 80, 211
Pope, L. S., 157
Poppenhagen, A. R., 18
Poulton, B. R., 101
Pounden, W. D., 16
Premachandra, B. N., 118
Price, D. A., 240
Price, N. O., 199
Priode, B. M., 198
Pritchard, W. R., 78

Q

Quensenberry, J. R., 6, 39, 195
Quinn, L. Y., 76

R

Raeside, J. I., 242
Rakes, J. M., 202, 225
Ramage, C. H., 102
Raun, Arthur, 114
Rasmusen, B. A., 215, 216
Ray, M. L., 26, 169
Rebhan, H. J., 158
Reirson, Robert, 86
Reineke, E. P., 77, 113, 117, 204, 231
Reiners, F. G., 197
Rempel, W. E., 83
Reynolds, W. M., 10, 38
Reynolds, W. L., 203
Rhodes, V. J., 135
Rice, R. W., 91
Riggs, J. K., 34
Rimm, A. A., 131
Robinson, J. S., 36
Robinson, O. W., 123
Rollins, W. C., 24
Roubicek, C. B., 14
Ruliffson, W. S., 73

S

Saffle, R. L., 75, 136
Safford, J., 233
Salisbury, G. W., 220
Salsbury, R. L., 177
Soule, R. P., 162
Santolucito, J. A., 201
Scott, K. W., 154
Schmidt, D. A., 54, 57
Schultz, A. B., 234
Seerley, R. W., 54
Self, H. L., 123, 207, 210, 245
Sell, O. E., 104, 107
Sewell, R. F., 147
Shaw, R. A., 78
Sheppard, A. J., 110
Shelby, C. E., 2, 5, 6
Sherman, W. C., 10, 38
Shrode, M. C., 32, 34
Shrode, R. R., 244
Sidwell, G. M., 126
Sisk, L. R., 104
Shirley, R. L., 181
Smith, Charles, 140
Smith, E. F., 108
Smith, G. S., 44, 74, 89
Smith, H. R., 16
Smith, R. L., 34
Smith, W. H., 241
Snyder, W. W., 85
Speer, V. C., 61, 63, 76, 116

Spies, H. G., 207
Spruth, H. C., 152
Stephens, D. F., 157
Stephenson, E. L., 161
Stob, Martin, 241
Stokes, D. K., 134
Stokstad, E. L. R., 53
Stone, E. J., 129
Stormont, C., 215, 216
Stouffer, J. R., 142
Straughn, A. A., 137
Stratton, P. O., 87, 120
Stroble, C. P., 8
Stroud, J. W., 48, 94, 176
Struempler, Arthur, 206
Sumption, L. J., 83
Sutton, D. D., 75
Suzuki, Y., 215, 216
Swanson, E. W., 111
Swift, R. W., 97
Sykes, J. F., 69, 200

T

Tallis, G. M., 27
Taylor, J. C., 23
Ternan, P. R., 2
Terrill, C. E., 127
Terrill, S. W., 59, 64, 148
Thomas, O. O., 39, 62, 195, 233
Thomas, W. E., 109
Thompson, Alan, 196
Thompson, C. B., 160
Tillman, A. D., 43
Tilton, Stuart, 62
Tollett, J. T., 161
Torell, Clark, 171
Trenkle, Allen, 175
Tribble, L. F., 164
Twiehaus, M. J., 73
Turkheimer, A. R., 237, 238
Turk, R. M., 21
Turner, C. W., 71, 118, 119
Turner, J. K., 159
Tyler, W. S., 29

U

Udall, R. H., 217
Ullrey, D. E., 54, 57, 75
Underwood, J. K., 166
Uren, A. W., 205

V

Varnell, T. R., 14
Varney, W. Y., 139
VanDemark, N. L., 66, 185, 221
Vandersall, J. H., 239
Van Horn, J. L., 233
Verma, I. S., 178

W

Wade, M. A., 171
Wagner, J. F., 204
Wagnon, K. A., 24
Wahlstrom, R. C., 65
Wallace, H. D., 60, 137, 150, 163, 209
Waller, G. R., 172
Walker, G. L., 108
Warner, R. G., 12, 88, 180
Ward, R. E., 165
Warnick, A. C., 31, 33, 203, 209, 218
Warren, E. P., 219
Warwick, B. L., 22
Warwick, E. J., 212
Watkins, T. D., 49
Webb, R. J., 103, 173, 183
Weir, W. C., 50
Welch, J. A., 44, 74, 89
Wellington, G. H., 142, 236
West, D. R., 54
West, R. G., 144
Whatley, J. A., 121, 124
White, E. A., 38
White, F. E., 127
White, T. W., 176
Williams, J. A., 227
Williams, J. S., 244
Williamson, J. L., 41, 170, 182, 186
Willman, J. P., 88
Willson, F. S., 39, 195
Wiltbank, J. N., 212
Winchester, C. F., 11
Winters, L. M., 83
Woodward, R. R., 6, 39, 195
Worthington, R. E., 98
Washburn, R. G., 35
Wrenn, T. R., 200

Y

Young, D. C., 237, 238

Z

Zeller, J. H., 20, 84
Zimbelman, R. G., 208
Zimmer, P. R., 95
Zimmerman, D. R., 210
Zucker, Hermann, 162

NEWS AND NOTES

1957 Annual Meeting. The annual meeting of the American Society of Animal Production will be held at the Hotel Sherman, Chicago, Illinois, on November 29 and 30.

The Nominating Committee of the American Society of Animal Production has proposed the following slate of candidates at the annual business meeting: for President W. M. Beeson; for Vice President, R. F. Cox and W. P. Garrigus; for Secretary-Treasurer, H. H. Stonaker.

Ralph W. Phillips has accepted the position of Director of International Organization Affairs, Foreign Agricultural Service, U. S. Department of Agriculture in Washington, D. C. Dr. Phillips was with the Food and Agriculture Organization of the United Nations for ten years, first as Chief of the Animal Production Branch and since 1949 as Deputy Director of the Agriculture Division, with headquarters in Rome, Italy.

Richard D. Appleman recently joined the staff of the Dairy Department at the University of Maryland as an Extension Instructor. He received his undergraduate and Master's degree from Oklahoma A & M. During the past two years he has been serving in the Armed Forces in a research capacity with livestock at Edgewood Arsenal in Maryland.

Roger Hemkin joined the staff at the University of Maryland on August 1 in the position of Assistant Professor. He will be doing research and teaching in the Dairy Production Field.

Richard G. Saacke recently assumed the position of Instructor in Extension in the Dairy Department, University of Maryland. He obtained his undergraduate training at Rutgers University and his Master's degree from Pennsylvania State University. He has also just completed a two year tour of duty with the Signal Corps in the U. S. Army.

Robert B. Casady, formerly Associate Professor in Animal Industry and Zoology at North Carolina State College, has been appointed Director of the U. S. Rabbit Experiment Station, Fontana, California, succeeding George S. Templeton who retired after 23 years of service.

J. C. Taylor, who has completed the requirements for a Master's degree at Virginia Polytechnic Institute in Animal Breeding, has accepted a position at Mississippi State College. He will work with beef cattle.

Carl Williams, who received the Master's degree from Texas Technological College, will coach the Livestock Judging Team at Mississippi State College.

Rodney L. Preston recently completed a Ph.D. degree at Iowa State College. He has accepted a position as Assistant Professor of Animal Husbandry at the University of Missouri.

Gustav Bohstedt, distinguished teacher, researcher and writer in the field of Animal Husbandry, has retired from the University of Wisconsin Animal Husbandry Department and in September began a teaching assignment as Visiting Professor in the Southern Illinois University School of Agriculture at Carbondale.

C. C. O'Mary has resigned from the University of Georgia to accept a position as Associate Professor, Department of Animal Science, State College of Washington, Pullman.

Paul A. Putnam completed a Ph.D. degree in Animal Nutrition at Cornell and has accepted a research position in the Animal and Dairy Husbandry Research Service, USDA, Beltsville, Maryland.

Donald Horvath accepted a position in the Animal Husbandry Department at the University of West Virginia, Morgantown, after completing a Ph.D. degree in Animal Nutrition at Cornell University.

James J. Drain finished a Ph.D. degree at Cornell University in Animal Husbandry in September and has accepted a position in the Farm and Home Division, American Cyanimid Company, Pearl River, N. Y.

The second edition of Swine Science (formerly Swine Husbandry) by M. E. Ensminger, Chairman, Department of Animal Science, State College of Washington, was published recently by the Interstate Printers and Publishers, Danville, Illinois. This revised text gives increased emphasis to meat-type hogs, the several new breeds, and the problems associated with the change from fat-type hogs to meat-type. The book is well organized and illustrated, and is very readable. The objectives of the first text to provide both a practical and scientific text have been kept in mind. The author has incorporated many reseach findings which seem to represent practical advances. The book is a good condensation of the most recent developments in swine production and management. It will be most useful in high school and college short courses but also has a place as a college textbook.—J. A. Hoefer

SUBJECT INDEX OF ORIGINAL ARTICLES FOR VOLUME 16

A

Adrenals—
  Extramedullary myelopoiesis, 341
Alfalfa—
  Cellulolytic factors in, 502
  Estrogens in, 850
  N fertilization on nutritive value of, 467
Alfalfa ash—
  Effect on roughage digestion, 633
Alfalfa hay—
  From low-sulfur soil, 451
Amino acids—
  Isoleucine for weanling pigs, 26
Ammoniated products for cattle, 179
Amylase—
  Effect on starch digestion, 370
Antibiotics—
  And hormones for fattening steers, 845
Animal fat and DPPD for swine, 911
Anthraquinone violet—
  Use as indicator, 688

B

Baby pigs—
  Diet and livability of, 877
  Protein and fat requirements of, 885
Barley—
  B vitamins in fresh and stored, 711
Beef—
  Consumer preference of, 233
Behavior patterns of sheep and cattle, 773
Bentonite for steers, 858
Birth weights of lambs, 130
Bloat, feedlot—
  Factors in frothy, 515
Bloat studies, 165
Boars—
  Protein for pasture and drylot feeding, 607
Bruised tissue—
  Determining age of, 490
  Factors affecting experimental, 496

C

Calcium—
  And trace elements in parakeratosis, 578, 589
  Biological value of, 437
Calorie value of TDN, 541, 753
Cancer eye of cattle—
  Relationships of pigmentation, 639
  Studies of, 1007
Cane molasses, ammoniated—
  Use of by sheep, 419
Carcass evaluation—
  Splitting and cutting errors in, 485
Carcass measurements—
  Prediction by live probe and lean meter, 481
Carotene—
  For beef cows and calves, 525
Casein hydrolysate—
  Cellulolytic factors in, 502
Cattle—
  A comparison of Brahman and British crossbred, 207
  Carotene and vitamin for, 525
  Conformation and carcass traits, 227
  Cooling by air movement, 732
  Effect of fungicide-treated corn on, 93
  Effect of protein and energy restriction on, 426
  Grazing habits of, 681
Cellulolytic effects of nutrients, 781
Chamise—
  Digestibility of, 467
Chlortetracycline—
  And salicylic acid for calves, 854
  Effect on calf carcasses, 654
  Effect on carcass composition of swine, 74
  Effect on roughage digestion, 110
  On pantothenic acid requirement, 35
  With stilbestrol and fat for steers, 833
Climatic stress on tropically reared cattle, 725
Conception among ewes—
  Effect of pastures on, 703
Corn silage—
  Effect on development of bulls, 158
Cottonseed meal—
  Degossypolized for swine, 12, 357
Creatinine and carcass composition, 961

D

Dairy cattle—
  Effect of corn silage on development of bulls, 158

Dairy cows—
Thyroid uptake of I^{131} in, 318
Deer—
Digestibility of live oak and Chamise by, 476
Diet and livability of baby pigs, 877
Digestion and balance equipment, 100
DPPD and fat for swine, 911

E

Enzymes—
Proteolytic on protein use by newborn pigs, 568
Equipment for feeding range cattle, 872
Estrogenic activity of bovine urine, 698
Estrogens in alfalfa, 850

F

Fat—
In diet and carcass fat, 68
Fats and oils—
Digestion by young pigs, 377
Feather meal as protein for lambs, 118
Female hormone for fattening steers, 845
Fetal pig weight, 976
Fistula, duodenal—
Establishment of, 692
Forages—
Dry matter intake and feeding value of, 546
Forage use by steers and sheep, 757

G

Gossypol tolerance of pigs, 364
Grazing habits of beef cattle, 681
Growth—
Of steer progeny groups, 217

H

Ham composition and carcass leanness, 85
High temperature and semen of rams, 328
Hormones—
Steroid, for fattening lambs, 283

L

Ladino clover—
Inhibition of biological systems, 711
Lambs—
Androgenic compounds for fattening, 294
Lambs—Cont.
Estrogenic compounds for fattening, 294
Estrogenic activity of excreta, 307
Steroid hormones for fattening, 283
Lean meter—
And live probe for predicting carcass measurements, 481
Live oak, Interior—
Digestibility of, 476
Live probe—
And lean meter for predicting carcass measurements, 481
Lysine requirement of pigs, 553, 558

M

Maltose utilization by newborn pigs, 574
Meat quality—
Ration and inheritance on, 946
Meat-type steers, 224
Menhaden oil for swine, 917
Metabolic fecal phosphorus—
Determination of, 201
Multiple birth in Rahmani sheep, 990

N

Nitrogen fertilization on nutritive value of orchard grass, 462

O

Oat hay—Stage of maturity on feeding value, 623
Orchard grass—
N fertilization on nutritive value, 462
Oxytetracycline—
On carotene and vitamin A storage, 828

P

Pantothenic acid for pigs, 396
Effect of chlortetracycline on, 35
Parakeratosis—
Calcium and zinc on, 3, 578, 589
Effect of feeding method on, 927
Parasites of lambs—
Effects of minerals and phenothiazine on, 937
Parathroidectomized goats, 312
Pasture and drylot feeding of swine, 562
Pelleted feeds for lambs, 863
Phosphorus—
Availability of supplements for beef, 444

Phosphorus—Cont.
Determination of metabolic fecal, 201
Fertilization on alfalfa for rabbits, 467
Utilization by ruminants, 796
With excess Ca for calves, 811
Photographic grid for rib eyes, 957
Pigs—
Starch digestion by, 370
Pilchard oil for swine, 922
Piperazine—
For control of ascarids, 943
Pork carcass grades—
Lean cut yields of, 642
Pregnancy in ovariectomized ewes, 986
Proceedings of annual meeting, 249
Progesterone—
Effect on follicular development and pituitary hormonal content, 151
On ovariectomized cows, 967
Protein supplements for sheep, 675
Protein levels—
For boars on pasture and drylot, 607

R

Rams—
Temperature and humidity on, 144
Rumen factors—
In yeast, alfalfa and casein, 502
Rumen fluid—
Surface tension and pH of, 190

S

Salicylic acid for calves, 854
Sewage as Nitrogen source for sheep, 125
Semen production of rams, 328
Self feeding steers, 787
Selective grazing, 766
Selection index—
Emphasis on components of, 349
For beef cattle, 998
Sheep—
Creep rations for, 413
Effect of pastures on conception, 703
Protein supplements for, 675
Temperature on ram fertility, 136
Value of low-sulfur alfalfa for, 451
Silage—
And plane of nutrition for sows, 600
Steers—
Free choice vs mixed rations for, 787
Stilbestrol—
And nor-testosterone for lambs, 840
Effect on digestibility and mineral retention, 821
Stilbestrol—Cont.
On vitamin A storage, 821
Excretion in feces and urine, 307
For fattening swine, 20
Implants for swine, 901
On growth and carcass characteristics, 662
Sugar—
Effect on protein and fiber digestion, 55
Supplements for swine, 892
Swine—
Carcass quality and plasma lipids, 62
Corn silage for, 600
Digestion at young ages, 383
Digestion of fats and oils by, 377
Effect of dietary fat on carcass, 68
Free choice and complete rations for, 562
Isoleucine for weanlings, 26
Lysine requirement of, 553, 558
Oral stilbestrol for fattening, 20
Ovulation and litter size, 335
Prenatal mortality and litter size, 335
Protein requirements for early weaned, 389
Protein supplements for, 12, 357
Utilization of nutrients by, 568, 574

T

TDN—
Calorie value of, 541, 753
Temperature and fertility of rams, 136
Thyroid uptake of I^{131}, 318
Tocopherol—
Feed and tissue relationships for calves, lambs and pigs, 612
Type, performance and carcasses, 240

U

Urea utilization by swine, 44

W

Whey, dried—
High levels for pigs, 404

Y

Yeast—
Cellulolytic factors in autolyzed, 502
Live cell on digestibility and N retention, 671

Z

Zinc—
Calcium and trace elements for pigs, 578, 589

AUTHOR INDEX OF ORIGINAL ARTICLES

A

Allen, R. S., 190
Anderson, D. E., 739, 1007
Andrews, F. N., 845, 850
Anglemier, A. F., 917, 922
Arthaud, V. H., 93, 811
Ashton, G. C., 44, 396, 600, 607, 885

B

Bacon, E. L., 612
Baker, F. H., 781
Barnhart, C. E., 396
Barrick, E. R., 68
Beall, G., 612
Becker, D. E., 26, 389, 404, 553, 558, 562
Beeson, W. M., 413, 589, 787, 845
Bell, M. C., 821
Bell, D. S., 703
Benne, E. J., 85
Bentley, O. G., 502
Bemrick, W. J., 937
Bertrand, J. E., 654
Bissell, H. B., 476
Blake, J. T., 190
Blazer, R. E., 681
Blosser, T. H., 100
Blue, R. L., 828
Blumer, T. N., 68
Bogart, Ralph, 130
Bohman, V. R., 833
Bond, T. E., 732
Brady, D. E., 233
Brammell, W. S., 3
Brannon, W. F., 525
Bray, R. W., 74, 642
Briggs, J. E., 943
Brinkman, D. C., 698
Brisson, G. J., 370, 568, 574
Bowland, J. P., 62
Bratzler, L. J., 481
Brown, W. L., 68
Burroughs, W., 294
Butler, O. D., 227, 946

C

Calvin, L. D., 130
Cartwright, T. C., 946
Casida, L. E., 144, 224, 976, 986
Carmon, J. L., 357
Carroll, F. D., 662
Catron, D. V., 44, 396, 600, 607, 885
Chambers, Doyle, 739, 1007
Chapman, A. B., 976
Cheng, E. W., 307
Christian, R. E., 349
Clegg, M. T., 662, 901
Cole, H. H., 151
Cook, C. W., 872
Conner, H. G., 692
Conrad, J. H., 589
Cover, Sylvia, 946
Crampton, E. W., 377, 383, 541, 546
Crowder, H. M., 437
Croom, H. G., 118
Crown, R. M., 654
Culbertson, C. C., 600
Cunha, T. J., 35
Cunningham, H. M., 370, 568, 574

D

Davis, B., 444
Davis, R. E., 165, 515
Davis, R. L., 850
Davis, R. R., 703
Deatherage, F. E., 490, 496
de Alba, Jorge, 725
deBaca, R. C., 130
deCosta, L. C., 688
Dehority, B. A., 502
Dicks, Martha W., 612
Doetsch, R. N., 515
Dolge, K. L., 612
Dowe, T. W., 93, 811
Dutt, R. H., 136, 328
Dyer, I. A., 828, 858

E

Eaton, H. D., 612
Edwards, H. N., 633
Elam, C. J., 858, 911
Ellis, N. R., 877
Emerick, R. J., 937
Emmerson, M. A., 967
Eness, P. G., 967
Engle, P. H., 703
Ensminger, M. E., 467, 828, 911
Erb, R. E., 100
Erwin, E. S., 858
Esplin, A. L., 863
Evans, J. L., 110

F

Flatt, W. P., 688
Flipse, R. J., 158
Flower, A. E., 217
Foley, R. C., 341
Foote, W. C., 144, 976, 986
Forbes, R. M., 796, 863

G

Gallup, W. D., 179, 419, 444, 671, 675
Garrigus, U. S., 796, 863
Gesler, J. T., 911
Gooch, L. D., 986
Gorski, J., 100
Goss, H., 719
Grainger, R. B., 110, 781
Greenstein, J. S., 341
Grummer, R. H., 578, 927
Guthrie, J. E., 943

H

Hackler, L. R., 125
Haines, C. E., 12
Hale, F., 364
Hale, W. H., 294, 307
Hamdy, M. K., 490, 496
Ham, W. E., 467

Hamm, P. T., 328
Hanka, L. J., 967
Hansard, S. L., 437
Hanson, L. J., 404
Harper, C., 413
Harris, B., 654
Harris, L. E., 872
Hatfield, E. E., 796, 863
Hays, V. W., 44
Hazel, L. N., 607
Heitman, Hubert, 901
Henneman, H. A., 283
Heinemann, W. W., 467
Helmboldt, C. F., 612
Hiner, R. L., 426
Hironaka, R., 62
Hodgson, A. S., 100
Hoefer, J. A., 3, 481
Hoekstra, W. G., 578, 927, 937
Horvath, D. J., 688
Hubbert, F. E., 525, 558, 562
Huffman, C. F., 692
Hull, J. L., 623, 757, 766, 773
Hunter, J. E., 833
Hutchinson, H. D., 553

J

Jackson, H. D., 711
Jacobson, D. R., 165, 515
Jacobson, N. L., 190
James, J. C., 872
Jensen, A. H., 26, 389, 404, 553, 558, 562
Johnson, B. Conner, 125
Johnson, C. W., 600
Johnson, R. R., 502
Jones, L. G., 623
Jordan, R. M., 118, 840
Jungherr, E. L., 612

K

Karam, H. A., 990
Keen, B. C., 357
Kelly, C. F., 732
Kelly, R. F., 74
Kincaid, C. M., 681
Kline, E. A., 485
Knox, J. H., 240
Kock, B. A., 719
Koger, M., 12
Kunkle, L. E., 490, 496

L

Landagora, F. T., 654
Lasley, E. L., 335, 485, 607
Lengemann, F. W., 318
LeGendre, L. R., 671
Lewis, P. K., 578, 927
Lindahl, I. L., 165, 515
Lindholm, H. B., 998
Liu, C. H., 44
Lloyd, L. E., 377, 383, 541
Lofgreen, G. P., 201, 719, 757, 766, 773
Long, T. A., 444
Loosli, J. K., 55
Luecke, R. W., 3
Luick, J. R., 201
Lush, J. L., 739, 1007
Lyke, W. A., 437
Lyman, C. M., 364

M

Macdonald, G. J., 462
MacKay, V. G., 383, 541
Magee, W. T., 481
Matsushima, J., 93, 811
McCormick, W. C., 207
McGilliard, A. D., 692
McKigney, J. I., 35
McLaren, G. A., 179
McNeill, J. J., 515
Meade, R. J., 892
Meites, J., 283
Melampy, R. M., 967
Meyer, J. H., 623, 719, 757, 766, 773
Mohler, Martin, 787, 845
Monroe, R. A., 318
Moxon, A. L., 502
Murdock, F. R., 100
Murphree, R. L., 821

N

Nellor, John, 151
Nelson, A. B., 444
Nelson, O. M., 130
Neumann, A. L., 125, 796
Nichols, R. E., 144
Norton, H. W., 26, 389, 553, 562, 796

O

Oldfield, J. E., 467, 917, 922
O'Mary, C. C., 20

P

Pauls, J., 307
Pearson, A. M., 85, 481
Peo, E. R., 885
Perry, T. W., 413, 787, 845
Phillips, P. H., 74, 937
Pope, A. L., 144, 937, 986
Pope, L. S., 179
Poulton, B. R., 462
Price, J. F., 85, 481
Price, W., 179
Prouty, R. M., 612

Q

Quinn, L. Y., 396

R

Rakes, J. M., 967
Reierson, R. J., 642
Rendig, V. V., 451
Rheims, M. S., 496
Rusoff, L. L., 654
Rust, R. E., 283
Rousseau, J. E., 612

S

Sampaio, J. M. C., 725
Sawyer, W. A., 525
Scarborough, V. C., 426
Schmidt, D. A., 3
Schoonover, C. O., 957
Self, H. L., 642, 976
Sewell, R. F., 20, 357
Shaw, J. C., 165, 515
Shaw, R. A., 711
Shelby, C. E., 217
Sheppard, R. E., 681
Simpson, E. C., 136
Sirny, R. J., 633
Skipitaris, C. N., 55
Smart, W. W. G., 68
Smith, F. H., 68
Smith, I. D., 26
Smith, V. R., 312
Soni, B. K., 100
Southwell, B. L., 207
Speer, V. C., 44, 600, 607, 885
Stevenson, J. W., 877

Stewart, D. G., 688
Stob, Martin, 845
Stonaker, H. H., 998
Story, C. D., 307
Stott, G. H., 312
Stratton, P. O., 957, 961
Strother, A., 757
Summers, C. E., 781
Swanson, E. W., 318
Swift, R. W., 753

T

Taylor, B., 294
Taylor, J. R., 821
Tefft, C. W., 633
Teichman, R., 612
Terrill, S. W., 26, 389, 404, 553, 558, 562
Teter, W. S., 892
Thompson, C. M., 110
Tillman, A. D., 179, 419, 444, 633, 675
Totusek, R., 671

U

Urick, J., 217

V

Vander Noot, G. W., 462

W

Wade, M. A., 833
Waldorf, D. P., 976
Walker, C. W., 312
Wallace, H. D., 12, 35
Ward, J. K., 633
Warner, R. G., 55, 688
Warren, E. P., 20
Weir, W. C., 451, 476, 623
Weswig, P. H., 525
Wheeler, R. R., 525
Willson, F. S., 217
Winchester, C. F., 426
Wing, J. M., 854
Woods, W. R., 419, 675
Wuthier, P. P., 961

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